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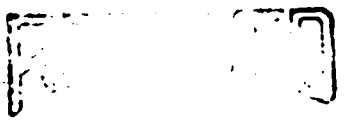

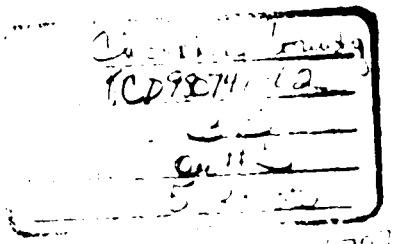

REMEDIAL INVESTIGATION

EXISTING DATA EVALUATION
GALENA SUBSITE

Final DRAFT

CHEROKEE COUNTY SITE
KANSAS

May 28, 1985

WORK ASSIGNMENT
127.7LB9.0

TABLE OF CONTENTS

I. INTRODUCTION

A. PURPOSE OF STUDY

The purpose of the Remedial Investigation at Cherokee County is to assess the nature and extent of environmental impacts caused by past mining activities in the Kansas portion of the Tri-State Mining area. The investigation is to focus on water quality degradation, acid mine drainage, subsidence and other geologic hazards, erosion of tailings piles, air quality impacts, and other environmental problems. The study addresses the impacted portions of Cherokee County, Kansas and will assess how those past mining activities in this area are currently impacting the environment or posing a significant health hazard.

As part of the Remedial Investigation activities, available data and scientific literature on Cherokee County were gathered, reviewed and compiled into a data base for future use in site characterization and other phases of the project. The availability of data pertinent to the Cherokee County site was presented in the Remedial Investigation Phase I Report: Existing Literature Review and Evaluation (December 18, 1984).

The purpose of the present study was to characterize the Galena portion of the Cherokee County site using the existing data base. The characterization was performed to:

- Assess whether potential environmental or human health hazards associated with abandoned mining activity in the Galena area are supported by the existing data base.

- Identify if additional sampling is required to fill data gaps in preparation for the development of a work plan.

B. STUDY LIMITATIONS

The present study was performed using data available from a wide variety of independent and governmental sources. Actual sample documentation, sample collection techniques, analytical methods, and the extent of quality assurance/quality control procedures used varied significantly, depending upon the purpose of the investigation and the investigators affiliation. No attempt was made to obtain additional information on these items beyond that contained in the data source. Furthermore, in using the existing data base, it was assumed that sampling, laboratory analysis and quality assurance/quality control conformed to accepted procedures and practices at the time of sampling.

C. REPORT FORMAT

The Galena area existing data analysis is presented by environmental media in the same order as that previously used in the Existing Literature Review and Evaluation report.

For each environmental media, sampling locations are presented on a map of the Galena area. Each map is provided with the outline of the Galena subsite boundary which had been proposed in the Remedial Investigation Phase I report. The subsite boundary is based on the extent of physically disturbed areas (open shafts, chat piles, subsidence and collapse areas). Pertinent analytical data for each sampling location are presented in tabular form and summarized in a table and on the map. A brief narrative discussion is provided addressing each environmental media which summarized the results of the analysis.

D. DATA PRESENTATION FORMAT

Tables are used to summarize data by presenting the values for each chemical constituent which exceeds the applicable standard presented, and/or criteria discussed in Section II, Basis of Assessment. Concentration values below applicable standards or criteria are not presented in the tables. Each analysis for a chemical constituent performed at a sample location is evaluated against the standard or criteria applicable to that constituent. The sum of each individual test result reported at the sample location for which an applicable standard or criteria exists is indicated in the tables as "Total No. of Analyses." The sum of each individual test result reported at the sample location which exceeded the applicable standard or criteria is indicated in the tables as "Total Exceedances."

Maps are used to provide locations of sampling points and to summarize the overall quality at the sampling location relative to applicable standards or criteria where chemical data are available. A circle divided into three quadrants is used as a map symbol in the summary. The upper half of the circle presents the location designation. The lower right quadrant contains the "Total No. of Analyses" from the table. The lower left quadrant contains the "Total Exceedances" from the table. The map presentation thus provides the total number of analyses which exceeded applicable standards or criteria and the total number of analyses performed. A comparison of these two numbers provides a general index of environmental quality at that location, and also indicates the size of the data base.

II. BASIS OF ASSESSMENT - STANDARDS AND CRITERIA

A. GENERAL ASSESSMENT

The data presented in this report have been evaluated by comparing the concentrations of each analytical parameter reported with applicable air and water quality criteria or standards. The applicable criteria or standards used are those which match the type of exposure most likely to be encountered for a given environmental medium. Chemical constituents that were evaluated against the standards were selected from the available data based on their probability of being likely contaminants in the Galena area (i.e. guidance from the Tar Creek Remedial Investigation/Feasibility Study) and their potential for posing a hazard to human health.

Where criteria or standards are not available for comparison, the potential hazards are less discernable since contaminant levels are not legally defined. In these cases, sample parameters must be assessed in terms of their relationship to "background" concentrations, if included in the data base, or to concentrations generally accepted as representing normal values.

B. GROUND WATER

Due to the utilization of ground water in the Galena area as a domestic water supply, Federal Interim Primary and Secondary Drinking Water Standards (40 CFR 141, 40 CFR 143) were applied to assess contamination. In absence of a specific drinking water standard for a critical chemical constituent, USEPA Surface Water Quality Criteria (45 CFR 231) were applied to assess whether sampled concentrations should be considered acceptable to protect human health. Both the Federal Drinking Water Standards and the USEPA Surface Water Quality Criteria are generally adopted by state governments as a basis for assessing the suitability of water for an intended use. Applicable Federal drinking water standards and water quality criteria are presented in Table II-1.

C. SURFACE WATER

Concentration values for criteria applied to surface water are dependent on the water use classification in both the Federal and Kansas State regulations. Individual criteria have been developed for the protection of aquatic life as well as the protection of human health. Kansas Administrative Regulations (Title 28, Article 16-28) establishes the "general criteria" for waste discharges to streams as follows:

> The individual and cumulative effect of waste discharges to waters of the state shall be guided by both the primary and secondary drinking water regulations found at 40 CFR 141 promulgated pursuant to P.L. 93-523 and by criteria for water quality published by the U.S. Environmental Protection Agency pursuant to Section 304a

TABLE II-1

APPLICABLE DRINKING WATER STANDARDS AND WATER QUALITY CRITERIA

Chemical or Parameter	Federal Primary DWS (mg/l)	Federal Secondary DWS (mg/l)	USEPA WQC(1)
Antimony	--	--	146
Arsenic	.05	--	2.2 ng/l(2)
Barium	1	--	--
Beryllium	--	--	3.7 ng/l(2)
Chloride	--	250	--
Cadmium	.01	--	10
Chromium (+6)	.05	--	50
Copper	--	1	--
Iron	--	0.3	--
Lead	.05	--	50
Manganese	--	.05	--
Nickel	--	--	13.4
Nitrate	10	--	--
pH	--	6.5-8.5	--
Silver	.05	--	50
Sulfate	--	250	--
Total Dissolved Solids	--	500	--
Zinc	--	5	--

(1) Maximum values for protection of human health; ingestion of water and organisms (all values in ug/l except as noted).

(2) 10^{-6} lifetime cancer risk.

> of P.L. 92-500. Pollutional substances contributed by man-made sources shall be controlled so that all waters are free from public health hazards or nuisance conditions at all times.

The Kansas Administrative Regulations further stipulate specific criteria for pH and limit the presence of toxic substances to concentrations which will not be harmful to animal, plant, or aquatic life or interfere with the designated water use.

Based on the above State criteria and applicable Federal criteria or standards, the surface water chemical concentrations were evaluated based on USEPA Surface Water Quality Criteria for protection of human health. In the absence of specific chemical criteria from either State or Federal sources, Federal Drinking Water Standards were applied to assess whether sampled concentrations should be considered acceptable. Therefore, sample parameter concentrations were compared first to applicable water quality criteria, and then to Drinking Water Standards.

D. AIR

Prior air quality sampling in the Galena area has been directly primarily towards monitoring levels of Total Suspended Particulates (TSP), settleable and respirable particulates, sulfur dioxide, and the quantity of selected metals in particulate samples. National Ambient Air Quality Standards (NAAQS) have been established for TSP, sulfur dioxide, and lead; and were applied in this report to assess contamination for these three parameters. The NAAQS are presented in Table II-2. Regulatory standards are not presently available to assess whether observed quantities of many metals on airborne material should be considered hazardous. Therefore, in this report the metal levels were compared, when possible, to averages published as part of the National Air Sampling Network (NASN). This NASN data library provides expected values that would be encountered in non-urban and urban areas (Table II-3).

E. SOIL

Regulatory standards or criteria are not presently available to assess whether chemical concentrations in soil should be considered hazardous to human health. In this report, soil comparisons were performed using "uncontaminated" or "background" concentrations established by the authors of each study containing soil analysis data. Due to differences in the analytical techniques used among the studies, the soil comparisons are relative within the individual data set contained in the particular study. The "uncontaminated" or "background" concentrations were compared to generally accepted concentration ranges found in native uncontaminated soils (shown on Table II-4) to check the rationality of the value. Evaluation of relative hazards was based on whether observed sample concentrations were in excess

Table II-2
NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	Primary Standard (Health)	Secondary Standard (Welfare)
Total Suspended Particulate	Annual Geometric Mean	75 ug/m^3[a]	60 ug/m^3
	24 hours[b]	260 ug/m^3	150 ug/m^3
	Monthly[c]	--	--
Ozone	1 hour[d]	235 ug/m^3	235 ug/m^3
Carbon Monoxide	8 hours	10 mg/m^3[e]	10 mg/m^3
	1 hour	40 mg/m^3	40 mg/m^3
Sulfur Dioxide	Annual Arithmetic Average	80 ug/m^3	--
	24 hours[b]	365 ug/m^3	--
	3 hours	--	1,300 ug/m^3
Nitrogen Dioxide	Annual Arithmetic	100 ug/m^3	100 ug/m^3
Hydrocarbons (Nonmethane)	3 hours[b] (6-9 a.m.)	160 ug/m^3	160 ug/m^3
Lead	Monthly	--	--
	Calendar Quarter Average	1.5 ug/m^3	1.5 ug/m^3

[a] Micrograms of pollutant per cubic meter of air.

[b] Not to be exceeded on more than 1 day per year.

[c] 24-hour average not to be exceeded for more than 15 percent of the samples in a calendar month.

[d] A statistical standard, but basically not to be exceeded more than an average 1 day per year based on the most recent 3 years of data.

[e] Milligrams of pollutant per cubic meter of air.

Table II-3
AVERAGE AND MAXIMUM METAL CONCENTRATIONS[a]
OF CERTAIN METALS IN 24-HOUR TSP SAMPLES
(NATIONAL AIR SAMPLING NETWORK)

Metal	Urban Area[b]		Non-Urban Area[c]	
	Maximum	Average	Maximum	Average
Cadmium	0.178	0.0019	0.031	0.0008
Copper	1.627	0.2593	4.003	0.1417
Iron	14.41	1.018	2.29	0.162
Lead	9.68	0.58	0.647	0.0842
Manganese	1.94	0.038	0.06	0.021
Nickel	0.207	0.0096	0.018	0.0032
Zinc	9.051	0.0263	0.326	0.0134

[a]Concentrations in $\mu g/m^3$

[b]Sample size, n = 2,507

[c]Sample size, n = 235

TABLE II-4

NATURALLY OCCURRING METAL
CONCENTRATIONS IN SOILS

Metal	Typical Concentration Range (ppm by wet wt.)
Cadmium	0.01 - 7
Copper	2 - 100
Lead	2 - 200
Manganese	100 - 4,000
Zinc	10 - 300

Source: Reference No. 3

TABLE II-5

NATURALLY OCCURRING METAL
CONCENTRATIONS IN PLANTS

Metal	Typical Concentration Range (ppm by wet wt.)
Cadmium	0.2 - 8.0
Copper	4 - 15
Lead	0.1 - 10
Zinc	8 - 15

Source: Reference No. 3

TABLE II-6

AVERAGE HEAVY METAL CONTENT OF FREEZER PRODUCE
PURCHASED IN SUBURBAN WASHINGTON, DC, 1971 - 1972

Produce	Average Concentration (ppm by weight) Cadmium	Lead	Zinc
Bean	0.24	9.2	53.5
Carrot	1.5	8.8	34.7
Lettuce	0.84	11.0	61.5
pea	0.42	6.6	53.2
Potato	0.28	10.2	25.8
Tomato	0.22	18.2	27.9
Rhubarb	0.57	15.1	52.5

Source: Reference No. 17

of those considered to be within the "normal" range of concentrations found in native soils.

F. BIOLOGICAL

The existing biological sampling performed within the Galena area was used only to provide insight into the net effects of chemical exposure at various points in the food chain. Although human exposure criteria are available for some results presented in the biological data, in-depth analyses and comparison of results to available human exposure criteria is more appropriately performed as part of an endangerment or exposure assessment. Therefore, available biological data was used primarily to verify the need for additional sampling of applicable environmental media.

In assessing the influence of mining effects on plants and human foods, information presented in Tables II-5 and II-6 were used as typical values in evaluating the rationality of "uncontaminated" or "background" concentrations from the existing data. If reasonable, the reported "uncontaminated" or "background" values were used as the basis in determining relative increases in concentrations.

III. GROUNDWATER RESOURCES

A. INTRODUCTION

Data on the groundwater resources of the Galena area were obtained from information sources obtained during preparation of the Remedial Investigation Phase 1 Report. Table III-1 presents a summary of information of known shallow and deep wells in the Galena area. Table III-3 presents a summary of information of known accessible mine shafts. Chemical analyses of water were reported from five of the shallow wells (S-115 to 118 and K-3), three of the deep wells (K-1, S-214 and S-215) and eight of the flooded mine shafts (M-23, M-24, M-28, M-29, M-30, M-31, M-33 and M-34) at locations shown on Drawing 84265-M2. Map number references to wells and mine shafts are as reported in the original references. An additional shallow well (S-127) and deep well (K-2) were located; however, no chemical analysis was reported in the available data base. Summaries of chemical data for the chemical analyses are presented on Tables III-2 and III-4.

The following sections present and evaluate available data on the shallow water-table aquifer (Warsaw, Burlington-Keokuk and Fern Glen Limestones) and the deep aquifer (Arbuckle Group).

B. SHALLOW AQUIFER

Chemical analyses representing the shallow water-table aquifer (Warsaw, Burlington-Keokuk, and Fern Glen Limestones) were available from five wells (S-115 to 118 and K-3) and from eight flooded mine shafts (M-23, M-24, M-28, M-29, M-30, M-31, M-33 and M-34) shown on Drawing 84265-M2. As can be seen by reference to Drawing 84265-M2, the flooded mine shafts are clustered in the vicinity of Galena, while the shallow well closest to Galena (S-115) is located over one mile to the west. Well S-115 is at the western edge of the mining disturbance surrounding Galena. The remaining shallow wells (S-116, S-117, S-118 and K-3) are even more removed from the mining disturbance centered near Galena.

As indicated in Table III-2, analyses of water from the five shallow wells exceeded drinking water standards for sulfate (twice), iron (twice) and manganese (three times).

Analyses of water from the eight flooded mine shafts, as indicated in Table III-4, exhibited an exceedance frequency for manganese drinking water standards similar to those observed in the shallow aquifer wells. The mine shaft samples, however, exceeded the cadmium and lead standards in 65 to 70 percent of the analyses performed while the shallow well samples did not exhibit any values above standards for these constituents. Depth stratified samples collected in the mine shafts generally indicated only small changes in water chemistry with depth.

TABLE III-1

SUMMARY OF KNOWN WELLS IN THE GALENA AREA

Map No.	Well Location	Reference No.	Date of Completion	Log and Construction Data Available	Depth	Base Formation	Aquifer Tapped	Water Level Date	Water Level Depth
S-115	USGS Sta # 370408094401201	20	NR	no	98	NR	Shallow	—	NR
S-116	USGS Sta # 370408094405401	20	NR	no	160	NR	Shallow	3/16/82	80 ft.*
S-117	USGS Sta # 370428094424401	20	NR	no	243	NR	Shallow	7/31/81	20*
S-118	USGS Sta # 370639094391201	20	NR	no	NR	NR	Shallow	—	NR
S-127	—	20	NR	no	244	NR	Shallow	—	NR
K-3	Riverton School District	13	May 1980	yes	241	NR	Shallow	5/27/81	30+
S-214	USGS Sta # 370659094403601 Jayhawk Ordinance Well	20,1	Jan. 1942	yes	901	Gasconde	Deep	—	NR
S-215	USGS Sta # 370421094381301	20	NR	no	1189	NR	Deep	—	NR
K-1	Galena City Well	13	Feb. 1979	yes	1260	NR	Deep	2/20/79	230+
K-2	Riverton School District	13	Dec. 1981	yes	1116	NR	Deep	12/22/81	90+

* Condition of well (pumping, idle, abandoned . . .) at time of measurement is unknown
\+ Water level at time of completion; stability questionable
NR Denotes "not reported"

TABLE III-2

SUMMARY OF GROUNDWATER ANALYSES
EXCEEDENCES OF DRINKING WATER STANDARDS OR
WATER QUALITY CRITERIA
(All concentrations in micrograms per liter except where noted)

Map No.	Sample Location	Date	Reference No.	pH mg/l	TDS mg/l	Sulfate mg/l	Chloride mg/l	Nitrate mg/l	Arsenic mg/l	Sb	Ba	Be	Cu	Cr	Cd	Pb	Ni	Aa	Zn	Fe	Mn	Total Exceed-ances	Total No. of Analyses	% Exceed-ance
S-115	Sec. 22, NW 1/4, Shallow Aquifer	7/30/81	20	—	—	—	—	—	—	NA	—	NA	—	NA	—	—	NA	NA	—	5700	100	2	13	15
S-116	Sec. 21, NW 1/4, Shallow Aquifer	3/16/82	20	—	—	—	—	NA	—	NA	—	NA	—	NA	—	—	NA	NA	—	3700	180	2	12	17
S-117	Riverton, Shallow Aquifer	7/31/81	20	—	NA	540	—	—	—	NA	—	NA	—	NA	—	—	NA	NA	—	—	420	2	12	17
S-118	Sec. 3, SE 1/4, Shallow Aquifer	3/16/82	20	—	—	—	—	—	—	NA	—	NA	—	NA	—	—	NA	NA	—	—	—	0	13	0
K-3	Riverton School Well, Shallow Aquifer	12/13/80	13	NA	NA	647	—	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	—	—	—	1	5	20
S-214	Sec. 4, Chemical Plant, Deep Aquifer	7/31/81	20	—	—	—	—	—	—	NA	—	NA	—	NA	—	—	NA	NA	—	—	—	0	13	0
S-215	Galena, Deep Aquifer	7/30/81	20	—	—	—	—	—	—	NA	—	NA	—	NA	—	—	NA	NA	—	—	—	0	13	0
K-1	Galena City Well Deep Aquifer	12/23/81	13	NA	NA	—	—	—	—	NA	—	NA	—	—	—	—	NA	NA	—	—	—	0	11	0

NA Not Analyzed

— Does not exceed Drinking Water Standards or Water Quality Criteria

TABLE III-3

SUMMARY OF KNOWN ACCESSIBLE MINE SHAFTS

Map Number	U.S.G.S. Station No.	Water Level Date	Water Level Elevation
M-22		8/11/81	860
		10/21/81	860
M-23	370447094381301	8/11/81	895
		10/21/81	895
		11/18/81	855
		3/15/81	855
		8/12/81	900
M-24	370527094315701	11/19/81	900
M-25		11/18/81	920
M-26		8/12/81	890
M-27		8/12/81	890
M-28	370520094365703	8/12/81	890
M-29	370520094365702	8/12/81	900
M-30	370441094371201	8/13/81	890
		11/21/81	890
M-31	370447094384701	8/14/81	865
		11/22/81	870
		3/16/81	870
M-32		8/14/81	860
M-33	370448094385501	8/14/81	855
		11/11/81	855
M-34	370415094381301	10/22/81	905

Reference No. 20

Note: McCauley (Ref:18) shows numerous other shafts in this area, but accessibility of these openings is unknown.

TABLE III-4

SUMMARY OF MINE WATER ANALYSES
EXCEEDENCES OF DRINKING WATER STANDARDS OR
WATER QUALITY CRITERIA

(All concentrations in micrograms per liter except where noted)

Map No.	Sample Depth (ft.)	Date	Reference No.	pH	TDS mg/l	Sulfate mg/l	Chloride mg/l	Nitrate mg/l	Arsenic mg/l	Sb	Ba	Be	Cu	Cr	Cd	Pb	Ni	Ag	Zn	Fe	Mn	Total Exceed-ances	Total No. of Analyses	% Exceed-ance
M-23	Surface	8/11/81	20	—	NA	—	—	—	—	NA	—	NA	—	NA	220	1900	NA	NA	—	—	—	2	12	16
M-23	50	3/15/82	20	—	—	—	—	NA	—	NA	—	NA	—	NA	200	1400	NA	NA	—	—	—	2	12	16
M-23	40	3/15/82	20	—	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	1	0
M-23	32	3/15/82	20	—	—	—	—	NA	—	NA	—	NA	—	NA	230	900	NA	NA	—	—	60	3	12	25
M-24	24	8/12/81	20	5.2	NA	350	—	—	—	NA	—	NA	—	NA	40	—	NA	NA	72	58000	680	6	12	50
M-24	30	11/19/81	20	4.2	—	—	—	—	—	NA	—	NA	—	NA	—	—	NA	NA	—	—	240	2	13	15
M-28	18	8/12/81	20	3.7	NA	—	—	—	—	NA	—	NA	—	NA	340	250	NA	NA	—	—	180	4	12	33
M-29	19	8/12/81	20	3.9	NA	—	—	—	—	NA	—	—	—	NA	340	240	NA	NA	—	—	180	4	12	33
M-30	Surface	8/13/81	20	3.9	NA	—	—	—	—	NA	—	NA	—	NA	320	—	NA	NA	—	—	170	3	12	25
M-31	18	8/14/81	20	4.7	NA	300	—	—	—	NA	—	NA	—	NA	20	—	NA	NA	60	—	510	5	12	42
M-31	21	3/16/82	20	4.7	—	290	—	NA	—	NA	—	NA	—	NA	150	380	NA	NA	79	—	660	6	12	50
M-31	25	3/16/82	20	4.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	1	100
M-31	30	3/16/82	20	4.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	1	100
M-31	35	3/16/82	20	4.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	1	100
M-31	40	3/16/82	20	4.7	490	290	—	NA	—	NA	—	NA	—	NA	—	240	NA	NA	79	—	660	6	12	50
M-33	Surface	8/14/81	20	3.6	NA	—	—	—	—	NA	—	NA	—	NA	50	60	NA	NA	—	—	300	4	12	33
M-34	13	10/22/81	20	3.6	NA	—	—	—	—	NA	—	NA	—	NA	140	260	NA	NA	—	—	410	4	12	33

NA Not Analyzed
— Does not exceed Drinking Water Standards or Water Quality Criteria

C. DEEP AQUIFER

Chemical analyses from three wells (K-1, S-214, and S-215), as shown on Drawing 84265-M2, were available representing the deep aquifer (Arbuckle group). Wells K-1 and S-215 are located in Galena. Well K-1 is the source of drinking water for the Galena municipal water supply. Well S-214 is located over three miles northwest across the Spring River from Galena.

As indicated in Table III-2, none of the analytical results exceeded applicable drinking water standards or criteria.

D. EVALUATION

The existing groundwater quality results indicate both chemical similarities and differences between the shallow aquifer wells sampled and the mine shafts sampled. The data suggest that concentrations exceeding drinking water standards for manganese may be characteristic of the shallow aquifer. This premise is supported by the presence of manganese concentrations in both well and mine shaft samples and absence of high concentrations of other constituents (cadmium and lead) found in the mine shaft samples.

The high concentrations of cadmium and lead observed in the mine shaft samples were not found in either the shallow well or deep aquifer well samples. Due to the association of these constituents with the mines, examination of cadmium and lead levels in future studies may provide insight when tracing contamination from the mine source. The available data base does not indicate existing cadmium or lead contamination of the shallow or deep aquifer.

However, the observations detailed above are based on the information contained in the available data base. Information on local groundwater flow direction and velocity is not contained in the data base and the observations stated should be considered in view of these shortcomings. Constituents may be moving at a velocity which has not permitted the contamination to migrate laterally to the shallow wells located far to the west of Galena or vertically to the deep wells sampled. Additionally, the shallow wells sampled may not be hydraulically connected to or downgradient from the mines.

The possible relationship between the mines and the contamination of the shallow groundwater has been conceptually described previously by Spruill, 1984 (Ref. No. 20), however more specific information related to private shallow groundwater use and location of the use is required to evaluate the potential risk to the public health.

IV. SURFACE WATER QUALITY

A. INTRODUCTION

The Galena area is drained primarily by two streams: Short Creek, which flows through the northern portion of Galena and enters Spring River above Empire Lake; and Shoal Creek which flows south of Galena and is impounded to form part of Empire Lake. The area is also drained by a small tributary entering Spring River south of Short Creek.

Spring River generally flows in a southwestern direction and, in addition to Short Creek and Shoal Creek, is fed by Turkey Creek from the east and Shawnee and Brush Creeks from the north. Turkey Creek flows from Missouri and enters Spring River several miles north of Galena. Shawnee and Brush Creeks drain the northern part of Cherokee County and enter Spring River from the western side. Although Turkey, Shawnee and Brush Creeks do not drain the Galena area, they contribute to the overall quality of Spring River and are necessary considerations in the overall data evaluations.

The available surface water data for the Galena area and Spring River is summarized in this section in Tables IV-1 and IV-2. Table IV-1 presents the data for sample locations where contamination was identified as exceeding the standards or criteria. Table IV-2 presents data at locations where there were no exceedances of standards or criteria. Data obtained from chat pile seepage and ponds in the area are also included. The data are presented in the tables and on the maps in a manner which illustrates the primary areas of concern for surface water quality, the major contaminants, and the areas where insufficient information is available for assessment.

B. SHORT CREEK DATA

Sixteen water samples have been taken between 1976 and 1982 at ten locations along Short Creek and its tributaries, beginning with one tributary in Missouri closest to the Kansas/Missouri State line and ending near its confluence with Spring River (see Drawing 84265-M1). In addition, seepage from chat piles and residential ponds have been sampled in areas above and below Short Creek.

In general, Short Creek enters the Galena area exhibiting some metals contamination. As indicated by the data presented in Table IV-1, the highest levels of contamination in Short Creek or its tributaries, are found in the section nearest to Galena (i.e., Map Locations 12, 13, and 14). The primary contaminants are cadmium, zinc and manganese, with two samples showing excessive lead levels. The pH of most of the samples taken in this area are below the acceptable standard of 6.5 to 8.5, ranging from 4.6 to 6.3.

The KDHE (1980) water quality results for Map Location 29 (Short Creek near Galena), are reported in terms of mean concentrations for the sampling period. With the exception of nitrate and chromium, all constituents exceed applicable standards and criteria.

TABLE IV-1

SURFACE WATER QUALITY SUMMARY
EXCEEDENCES OF WATER QUALITY CRITERIA OR DRINKING WATER STANDARDS

(All concentrations in micrograms per liter except where noted)

Map No.	Sample Location	Date	Ref. No.	Discharge(1) cfs	pH	TDS mg/l	Sulfate mg/l	Chloride mg/l	Nitrate mg/l	Arsenic	Sb	Ba	Be	Cu	Cr	Cd	Pb	Ni	Ag	Zn	Fe	Mn	Total Exceedances	No. of Analyses	% Exceedance
*	Tributary 1 to Short Creek, MO	8/12/81	20	.09	--	NA	--	--	--	--	--	--	NA	--	NA	--	--	NA	NA	--	--	80	1	13	8
8	Short Creek at KS/MO State Line	3/10/76	2	37	5.9	--	--	--	NA	NA	NA	NA	NA	--	--	--	--	17	--	--	440	200	9	36	25
		6/16/81	20	NA	--	NA	--	--	--	--	NA	--	NA	--	NA	--	--	NA	NA	--	--	120			
		8/12/81	20	1.4	6.0	NA	260	--	--	--	NA	--	NA	--	NA	20	--	NA	NA	--	--	860			
9	Spring Branch Near Galena	8/12/81	20	.27	--	NA	--	--	--	--	NA	--	NA	--	NA	20	--	NA	NA	--	--	--	1	12	8
10	Tributary 2 to Short Creek	8/12/81	20	.03	6.2	NA	--	--	--	--	NA	--	NA	--	NA	110	--	NA	NA	15,000	--	--	3	12	25
11	Tributary 3 to Short Creek	6/16/81	20	1.7	--	NA	--	--	--	--	NA	--	NA	--	NA	60	--	NA	NA	8,600	--	--	4	24	17
		8/12/81	20	.05	--	NA	--	--	--	--	NA	--	NA	--	NA	60	--	NA	NA	5,400	--	--			
12	Short Creek at Galena	6/16/81	20	81	--	NA	--	--	--	--	NA	--	NA	--	NA	70	--	NA	NA	7,000	--	640	11	36	31
		8/12/81	20	3.0	6.3	NA	280	--	--	--	NA	--	NA	--	NA	290	--	NA	NA	28,000	--	3,500			
		3/18/82	20	15	--	NA	--	--	--	--	NA	--	NA	--	NA	110	--	NA	NA	6,800	--	930			
13	Tributary 5 to Short Creek	8/12/81	20	.12	4.6	NA	--	--	--	--	NA	--	NA	--	NA	110	200	NA	NA	28,000	--	540	5	12	42
14	Tributary 5 to Short Creek	6/16/81	20	14	--	NA	--	--	--	--	NA	--	NA	--	NA	40	--	NA	NA	7,900	--	130	8	24	29
		8/12/81	20	1.7	--	NA	260	--	--	--	NA	--	NA	--	NA	150	200	NA	NA	44,000	--	370			
15	Short Creek 2 Miles W. Galena	8/12/81	20	5.0	6.0	NA	--	--	--	--	NA	--	NA	--	NA	170	--	NA	NA	25,000	--	1,700	4	12	33
29	Short Creek near Galena	Fall,78-Spring,79	8	NA	5.7	1258	500	NA	--	NA	NA	NA	NA	1,600	--	540	5,500	NA	NA	100,000	1,800	NA	8	10	80
6	Turkey Creek near Galena	8/14/81	20	16	--	NA	--	--	--	--	NA	--	NA	--	NA	--	--	NA	NA	--	--	140	1	12	8
16	Spring River Trib. near Galena	8/12/81	20	.41	--	NA	--	--	--	--	NA	--	NA	--	NA	--	--	NA	NA	--	--	90	1	12	8
*	Brush Creek near Riverton	Fall,78-Spring,79	8	NA	--	--	--	--	--	NA	NA	NA	NA	--	--	80	600	NA	NA	--	--	NA	2	10	20
*	Shawnee Creek	6/27/78	14	10.5	--	NA	--	--	13	NA	NA	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	1	4	25
21	Spring River 4 Miles NE Riverton	8/11/81	20	NA	--	NA	--	--	--	--	NA	--	NA	--	NA	--	--	NA	NA	--	--	160	1	12	8
22	Empire Lake at Riverton	8/11/81	20	NA	--	NA	--	--	--	--	NA	--	NA	--	NA	--	--	NA	NA	--	--	280	1	12	8
4	Wood's North Pond	3/31/81	7	NA	6.3	NA	--	--	--	NA	NA	NA	NA	NA	NA	20	--	NA	NA	--	NA	NA	2	7	29
17	Chat Seepage Site 1 near Galena	3/16/82	20	<.01	4.6	NA	--	--	--	--	NA	--	NA	--	NA	130	--	NA	NA	65,000	--	230	4	10	40
18	Chat Seepage Site 2 near Galena	3/16/82	20	NA	4.7	NA	--	--	--	--	NA	--	NA	--	NA	110	2,700	NA	NA	12,300	--	--	4	10	40
35	Gulf Chem. Co. Cooling Outlet	7/23/69	12	8	8.9	NA	--	--	--	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	330	160	15	49	31
		7/24/69	12	8	9.3	NA	--	--	--	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	310	220			
		7/25/69	12	7	9.6	NA	--	--	--	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	680	80			
		7/26/69	12	7	9.1	NA	--	--	--	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	--	--			
		7/27/69	12	7	9.2	NA	--	--	--	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	--	--			
		7/28/69	12	7	NA	NA	--	--	--	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	370	--			
		7/29/69	12	7	9.5	NA	--	--	--	NA	NA	NA	NA	NA	--	NA	NA	NA	NA	NA	360	140			

* Not on Map
(1) Not Regulated; Given for Sample Evaluation
NA = Not Analyzed
- = Does Not Exceed Drinking Water Standards or Water Quality Criteria

The chat seepage samples (Map Locations 17 and 18) show substantial levels of cadmium and zinc constituents which were also observed at high levels in the samples obtained from mine shafts (See II Ground Water Resources). Map Location 17 also shows a high concentration of manganese and Map Location 18 shows a high concentration of lead. These chat seepage sites are located within the drainage area of Short Creek and are probably representative of other chat piles that may be contributing to the overall metals contamination in the Galena area. This may be of particular importance in terms of surface water runoff during heavy rains. In addition, a sample from a residential pond north of Galena (Map Location 4) showed a cadmium concentration in excess of the standards. A high cadmium concentration may be the result of past mining activities, but this is the only one of five ponds (Locations 1 through 5) sampled in the same vicinity showing any metals contamination.

Discharge data available along Short Creek show a generally steady increase in volume of flow as the 8/12/81 sampling progressed downstream (1.4 cfs at Location 8 up to 5 cfs at Location 15). The increase cannot be attributed entirely to the tributaries entering Short Creek between Locations 8 and 15. There is insufficient information to determine whether the flow increase is due to non-point seepage, unmonitored discharge, or some other source. There is no indication from the existing data of loss of flow in Short Creek due to flow into mine workings. In order to determine the impact each tributary is having on the overall quality of Short Creek, and possible sources of metals, accurate discharge measurements of all the tributaries are necessary.

The data presented suggest that a human health hazard may exist in Short Creek as a result of heavy metal contamination. The most reasonable route of human exposure would be ingestion of contaminated water. Unless Short Creek is used as a drinking water source (or possibly for agricultural or recreational uses), it seems unlikely that significant exposure could occur.

C. SHOAL CREEK DATA

Multiple samples have been taken over time from Shoal Creek south of Galena (Map Locations 25 and 30). Data in Table IV-2 indicate that all chemical concentrations were within acceptable levels; however, only one sample, taken on April 5, 1983, had complete metals analysis data.

The lack of complete metals analysis and an inadequate number of sample locations along the creek prohibit an accurate assessment of the quality of Shoal Creek and its impact on the surrounding area. Additional samples should be taken from the tributaries entering Shoal Creek from the Galena area to assess possible impact of seepage from chat piles. Several of these tributaries, as seen on the map, pass through large areas of tailings piles as they drain the southern portion of Galena.

TABLE IV-2

SUMMARY OF SURFACE WATER SAMPLES
WHICH DO NOT EXCEED APPLICABLE STANDARDS OR CRITERIA

Map No.	Sample Location	Date	Ref. No.	No. of Analyses	Discharge cfs
25	Shoal Creek Near Galena	10/8/74	22	6	194
		12/10/74	22	6	500
		2/4/75	22	6	980
		4/2/75	22	6	1,500
		6/11/75	22	6	449
		10/6/82	10	5	138
		11/3/82	10	5	134
		11/30/82	10	5	687
		1/5/83	10	5	431
		2/8/83	10	5	566
		3/8/83	10	5	286
		4/5/83	10	14	NR
		5/10/83	10	5	NR
		6/7/83	10	5	NR
		7/5/83	10	5	NR
		8/2/83	10	5	NR
		9/6/83	10	5	NR
30	Shoal Creek Near Galena (Mean Conc.)	Fall, 1978 to Spring, 1979	8	10	NR
34	Shawnee Creek Near Gulf Chemical Co.	7/23/69	12	7	8
		7/24/69	12	7	8
		7/25/69	12	7	7
		7/26/69	12	7	7
		7/27/69	12	7	7
		7/28/69	12	7	7
		7/29/69	12	7	7
1	Bennett's North Pond	3/31/71	7	7	NR
2	Bennett's South Pond	3/31/71	7	7	NR
3	Mallatt's North Pond	3/31/71	7	7	NR
5	E. Fields' North Pond	3/31/71	7	7	NR

NR = Not Reported

D. SPRING RIVER AND TRIBUTARIES DATA

Two samples taken from Empire Lake, at Riverton and four miles northeast (Locations 21 and 22), indicate that only manganese exceeded its applicable standard. No other metal concentrations were above criteria or standards (see Table IV-1). Samples taken from the tributaries to Spring River show that each stream may be contributing some metal contamination, supporting the possible need for more sampling of Spring River. The sample from Turkey Creek (Map Location 6) indicates manganese contamination as does the sample in a tributary to Spring River east of Galena (Map Location 16). Excess levels of cadmium and lead were found in Brush Creek near Riverton (not located on map) while Shawnee Creek (also not on map) showed only an excess of nitrate.

Since Short Creek is potentially contributing the highest levels of contamination to Spring River, samples should be taken for metals analysis near its confluence. Samples should also be taken upstream of Short Creek on Spring River in an attempt to characterize the magnitude of any impact of Short Creek on Spring River. Note that the sample labeled "2" in Spring River upstream of Short Creek is a biological sampling point only.

E. EVALUATION

The data presented in Tables IV-1 and IV-2 suggest that the primary area where water quality exceeds criteria or standards is Short Creek north of Galena. Although insufficient evidence is available to assess the impact of other surface water sources on the Galena area, the data indicate that metal concentrations are acceptable at sample locations in Shoal Creek.

Spring River and the remainder of its tributaries have only been characterized superficially in terms of their relationship to the Galena area. Additional sampling and analysis appears to be warranted to confirm the existing data results and investigate unsampled tributaries draining mined areas along Spring River.

The data summarized in this section have been compiled from various sources and may not represent current stream conditions. However, levels of contaminants in samples taken from the same areas over the period of record indicate the persistence of some metals (e.g., zinc, manganese, cadmium, and to a lesser extent, lead) which may represent a hazard to human health if the possibility of exposure exists.

V. AIR QUALITY

A. INTRODUCTION

Limited air quality data are available to assess current air quality at the Cherokee County, Kansas site and in the Tri-State area. Studies measuring Total Suspended Particulates (TSP), settleable particulates, respirable particulates, sulfur dioxide (SO2) concentrations, and concentrations of metals on particulate filters have been performed. Most of the studies were conducted in the early 1970's near Galena just before and after the smelter closed, and in the early 1980's by the KDHE. The existing literature on air quality in the study area has been summarized in the Remedial Investigation Phase I Report (U.S. Environmental Protection Agency, 1984). The objectives of this report are to tabulate and evaluate air quality data for the Galena subsite, incorporate additional air quality data that has become available, and recommend a basic sampling approach for the Galena subsite.

As indicated in the following tables, most of the data have been obtained in the Galena area. Air quality data were collected during smelter activities in Galena and reflect historical air quality conditions. Data have also been collected recently (July-November 1983) that reflect ambient air quality near the major population centers.

B. TOTAL SUSPENDED PARTICULATE (TSP)

Total Suspended Particulate (TSP) levels have been measured for 5 years (1972-1976) in Galena, Kansas; for one year in Joplin, Missouri (1976); in March-April 1971 near Galena; in Picher, Oklahoma, during SeptemberOctober 1982; and at several populated areas during July-November 1983. These data are presented in Table V-1.

The 24-hour TSP Primary National Ambient Air Quality Standard of 260 mg/m (Table II-2) was exceeded only once at the Bennett Farm Site during the March-April 1971 study and once during the 1983 sampling at Treece, Kansas (Table V-1). The 24-hour TSP Secondary NAAQS of 150 mg/m has been exceeded, as shown in Table V-1, at 4 of the 16 locations sampled (Bennett's Farm, Wood's Farm, Mallatt's Farm, and Treece, Kansas), but the frequency of exceedence has been low.

An annual geometric mean concentration in the range of 10 to 60 mg/m TSP has been found to be representative of rural areas by the National Air Sampling Network (NASN). Typical urban values range from 60 to 200 mg/m. Data collected in the Cherokee County area generally ranges between 50 and 98 mg/m, indicating that TSP values have been higher than typical rural areas but in the low range of values for urban areas. The Primary TSP annual geometric mean was never exceeded near Galena but the Secondary TSP mean of 60 mg/m was exceeded in 1973, 1974, and 1976 (Table V-1).

Table V-1
SUMMARY OF TOTAL SUSPENDED PARTICULATE (TSP) ANALYSES EXCEEDENCES OF AIR QUALITY STANDARDS

Map No.	Sample Location	Date	Number of Observations	24-Hour NAAQS						Annual Geometric Mean ($\mu g/m^3$)	Reference
				Primary Standard			Secondary Standard				
				Number of Exceedances	Percent Exceedances	High ($\mu g/m^3$)	Number of Exceedances	Percent Exceedances	Second High ($\mu g/m^3$)		
1	Bennett's Farm	Mar-Apr 1971	30	1	3	314[a]	3	10	252[b]	98[d]	7
2	Wood's Farm	Mar-Apr 1971	33	0	0	200	1	3	147	68[d]	7
3	Mallatt's Farm	Mar-Apr 1971	34	0	0	179	1	3	142	66[d]	7
5	Galena	1972	14	--	--	131	--	--	87	56	23
5	Galena	1973	25	--	--	208	*	--	169[b]	62[c]	23
5	Galena	1974	40	*	--	261[a]	*	--	214[b]	64[c]	23
5	Galena	1975	29	--	--	165	--	--	121	49	23
5	Galena	1976	44	*	--	321[a]	*	--	167[b]	67[c]	23
--	Joplin	1976	48	--	--	113	--	--	91	50	23
--	Picher, OK	9-23-82 to 10-14-82	8	0	0	76	0	0	70	--	23

*At least once, not enough information to tell if exceedances greater than one.

[a] Exceeds Primary 24-hr TSP NAAQS of 260 $\mu g/m^3$.

[b] Exceeds Secondary 24-hr TSP NAAQS of 150 $\mu g/m^3$.

[c] Exceeds Secondary Annual TSP NAAQS.

[d] Not enough data for average period.

Table V-1
(continued)

Map No.	Site	Date	Number of Observations	24-Hour NAAQS						Annual Geometric Mean ($\mu g/m^3$)	Reference
				Primary Standard			Secondary Standard				
				Number of Exceedances	Percent Exceedances	High ($\mu g/m^3$)	Number of Exceedances	Percent Exceedances	Second High ($\mu g/m^3$)		
--	West of Treece, KS	7-17-83 to 11-26-83	15	0	0	118	0	0	94	--	11
--	Treece, KS	7-12-83 to 11-26-83	21	1	5	333[a]	5	24	167[b]	--	11
--	Baxter Springs, KS	7-17-83 to 11-26-83	23	0	0	223	0	0	134	--	11
14	City of Galena, KS	7-12-83 to 11-26-83	20	0	0	100	0	0	88	--	11
15	South of Galena, KS	7-23-83 to 11-26-83	15	0	0	120	0	0	78	--	11
--	Columbus, KS	7-17-83 to 11-26-83	22	0	0	107	0	0	97	--	11

[a] Exceeds Primary 24-hr TSP NAAQS of 260 $\mu g/m^3$.

[b] Exceeds Secondary 24-hr TSP NAAQS of 150 $\mu g/m^3$.

DE/CC/120

C. TSP FILTER ANALYSES

TSP samples collected during several studies in the Cherokee County area were analyzed to determine the concentrations of some of the heavy metals that might be expected to occur in a mining area. Tables V-2 and V-3 summarize these data by presenting the average concentration and the highest and second highest levels reported for each sampling station.

In 1970, samples were collected at three locations upwind and five locations downwind of the then active smelter in Galena. The concentrations of lead, zinc, and cadmium were all higher at locations downwind than upwind of the smelter (Table V-2). Zinc concentrations at downwind locations were approximately 24 times greater than at upwind locations. Lead and cadmium levels were about three and two times higher, respectively, at the downwind sampling locations. Lagerwerff and Brower (1975) concluded from these studies that the smelter was a source of heavy metal soil contamination in areas downwind of that facility.

Irwin (1971) sampled three locations near Galena in 1971 as part of an investigation of cattle illness at farms in the area. The arithmetic average of lead at the Bennett, Wood, and Mallatt farm sites was 0.53, 0.95, and 0.36 mg/m (Table V-2). All of these levels are below the NAAQS lead standard of 1.5 mg/m, but are more representative of urban than non-urban areas as indicated by data from the NASN (Table II-3). The cadmium levels in the TSP samples from the Bennett, Wood, and Mallatt farm sites are also shown in Table V-2. No ambient standard (NAAQS) has been established for cadmium. However, the cadmium levels reported from these three farms were considerable higher than cadmium levels observed in both urban and non-urban areas by the NASN (Table II-3). The Mallatt Farm, with the lowest lead and cadmium concentrations, was the only location where no cattle illness was occurring.

The TSP samples collected in Galena in May 1975 were analyzed for lead and zinc (Table V-2) and also for cobalt, chromium, copper, iron, manganese, and nickel (Table V-3). The lead levels (average of 0.31 mg/m) were well below the NAAQS standard of 1.5 mg/m, but similar to Irwin's (1971) data, the 1975 data were more representative of an urban than non-urban environment according the the NASN. The levels of the other metals analyzed in the 1975 study generally indicated that air quality at Galena compared to the higher non-urban or lower urban values reported by the NASN.

Tables V-2 and V-3 also include metal concentration data from a 1982 study near Picher, Oklahoma, from 1983 monitoring studies at six locations by the KDHE, and from data compiled by a legal firm in 1983 (Tar Creek Task Force, Health Effects Subcommittee, 1983 KDHE, 1984; and McKenna, Conner, and Cuneo, 1983). Lead data from these studies indicate that lead concentrations have not exceeded the NAAQS standard (Table II-2). Data for the other metals, in comparison to NASN data (Table II-3), indicate that air

Table V-2

SUMMARY OF AIR QUALITY SAMPLES (TSP) ANALYZED FOR LEAD, ZINC, AND CADMIUM LEVELS
CHEROKEE COUNTY, KANSAS

Map No.	Sample Location	Date	No. of Observations	Lead			Zinc			Cadmium			Ref
				1st[a]	2nd[b]	Avg	1st	2nd	Avg	1st	2nd	Avg	
6	Downwind of Active Smelter	1970	NA	--	--	0.52	--	--	4.60	--	--	0.09	17
6	Downwind of Active Smelter	1970	NA	--	--	0.40	--	--	7.9	--	--	0.03	17
7	Downwind of Active Smelter	1970	NA	--	--	0.81	--	--	6.84	--	--	0.08	17
7	Downwind of Active Smelter	1970	NA	--	--	0.4	--	--	5.7	--	--	0.02	17
10	Downwind of Active Smelter	1970	NA	--	--	0.95	--	--	4.51	--	--	0.16	17
11	Upwind of Active Smelter	1970	NA	--	--	0.28	--	--	0.34	--	--	0.03	17
12	Upwind of Active Smelter	1970	NA	--	--	0.26	--	--	0.24	--	--	0.06	17
13	Upwind of Active Smelter	1970	NA	--	--	0.16	--	--	0.18	--	--	0.04	17
1	Bennett's Farm	Mar-Apr 1971	30	3.32	2.06	0.53		NA		1.86	1.08	0.14	7
2	Wood's Farm	Mar-Apr 1971	33	5.65	4.82	0.85		NA		1.04	0.18	0.077	7
3	Mallatt's Farm	Mar-Apr 1971	34	1.14	1.08	0.36		NA		0.52	0.39	0.078	7
20	Galena, KS	5-6-75 to 5-30-75	5	0.41	0.35	0.31	0.71	0.54	0.49		NA		23
--	Picher, OK (Analysis on TSP)	8-23-82 to 11-11-82	7	0.22	0.13	0.06	1.75	1.67	1.48	0.04	<0.008	<0.008	24
--	Analysis on Respirable (10 micron) Particulates	8-23-82 to 11-11-82	7	0.199	0.008	0.035	2.75	2.51	2.02	0.03	<0.008	<0.008	24

[a] Highest level reported in the data set.

[b] Second highest level reported in the data set.

Table V-2
(continued)

Map No.	Sample Location	Date	No. of Observations	Lead			Zinc			Cadmium			Ref
				1st[a]	2nd[b]	Avg	1st	2nd	Avg	1st	2nd	Avg	
--	West of Treece, KS (TSP)	7-17-83 to 11-26-83	15	0.197	0.132	0.095	0.760	0.457	0.194	0.012	0.012	0.003	11
--	West of Treece, KS (inhalable particulate)	7-18-83 to 11-26-83	20	0.219	0.188	0.068	0.892	0.259	0.122	0.012	0.012	0.003	11
--	Treece, KS (TSP)	7-17-83 to 11-26-83	21	0.57	0.23	0.153	4.591	3.702	1.672	0.028	0.020	0.008	11
--	Treece, KS (inhalable particulate)	8-23-83 to 11-20-83	11	0.44	0.16	0.114	3.341	2.563	1.023	0.018	0.011	0.006	11
--	Baxter Springs, KS	7-17-83 to 11-26-83	23	0.365	0.226	0.136	2.990	1.659	0.442	0.01	0.01	0.003	11
14	City of Galena, KS	7-17-83 to 11-26-83	20	0.418	0.138	0.070	0.534	0.098	0.118	0.005	0.004	0.001	11
15	South of Galena, KS	7-23-83 to 11-26-83	15	0.250	0.230	0.119	0.311	0.163	0.096	0.007	0.003	0.001	11
--	Columbus, KS	7-17-83 to 11-26-83	22	0.177	0.146	0.067	0.296	0.270	0.113	0.008	0.008	0.003	11
16	Eagle Picher Plant Site A	1-21-83 to 2-11-83	5	0.20	0.10	0.10		NA		<0.005	<0.005	<0.005	19
17	Eagle Picher Plant Site B	1-21-83 to 2-11-83	5	0.20	0.10	0.10		NA		<0.005	<0.005	<0.005	19
--	Carl Wiles Treece, KS	1-21-83 to 2-11-83	5	0.15	0.10	0.10		NA		<0.005	<0.005	<0.005	19

[a] Highest level reported in the data set.

[b] Second highest level reported in the data set.

Table V-2
(continued)

Map No.	Sample Location	Date	No. of Observations	Lead			Zinc			Cadmium			Ref
				1st[a]	2nd[b]	Avg	1st	2nd	Avg	1st	2nd	Avg	
18	David Scott Galena, KS	1-21-83 to 2-11-83	5	0.10	0.05	0.05		NA		<0.005	<0.005	<0.005	19
19	Bob Scott Galena, KS	1-21-83 to 2-11-83	5	0.10	0.05	0.05		NA		<0.005	<0.005	<0.005	19
--	Dwight Trahin Baxter Springs, KS	1-21-83 to 2-11-83	5	0.10	0.05	0.05		NA		<0.005	<0.005	<0.005	19
--	Floyd Colvard Baxter Springs, KS	1-21-83 to 2-11-83	5	0.10	0.05	0.05		NA		<0.005	<0.005	<0.005	19
--	Walter Swalley Baxter Springs, KS	1-21-83 to 2-11-83	5	0.15	0.10	0.10		NA		<0.005	<0.005	<0.005	19

[a]Highest level reported in the data set.

[b]Second highest level reported in the data set.

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Table V-3
SUMMARY OF AIR QUALITY SAMPLES (TSP) ANALYZED FOR SELECTED METALS
CHEROKEE COUNTY, KANSAS

Map No.	Site	Date	No. of Observations	Cobalt			Chromium			Copper			Iron			Manganese		
				1st[a]	2nd[b]	Avg	1st	2nd	Avg	1st	2nd	Avg	1st	2nd	Avg	1st	2nd	Avg
20	Galena, KS	5-6-75 to 5-30-75	5	<0.0002	<0.0002	<0.0002	0.0093	0.0087	0.0076	0.32	0.087	0.102	0.97	0.77	0.58	0.15	0.15	0.077
--	Picher, OK (Analysis on TSP)	8-23-82 to 11-11-82	7		NA		<0.004	<0.004	<0.004		NA			NA		0.07	0.04	0.03
--	Analysis on Respirable (10 micron) Particulates	8-23-82 to 11-11-82	7		NA		<0.004	<0.004	<0.004		NA			NA		0.02	0.02	0.01
--	West of Treece, KS (TSP)	7-17-83 to 11-26-83	15	0.04	0.03	0.008	0.166	0.136	0.051	0.127	0.099	0.057	2.745	1.859	0.892	0.22	0.214	0.076
--	West of Treece, KS (inhalable particulate)	7-18-83 to 11-26-83	20	0.05	0.04	0.011	0.332	0.289	0.083	0.021	0.013	0.006	2.355	1.737	0.662	0.367	0.357	0.071
--	Treece, KS (TSP)	7-17-83 to 11-26-83	21	0.02	0.02	0.006	0.079	0.056	0.040	7.25	5.17	2.21	0.86	0.84	0.08	1.18	0.95	0.29
--	Treece, KS (inhalable particulate)	8-23-83 to 11-20-83	11	0.02	0.01	0.007	0.065	0.019	0.015	3.61	2.85	1.229	0.343	0.282	0.060	1.16	0.990	0.604
--	Baxter Springs, KS	7-17-83 to 11-26-83	23	0.04	0.03	0.01	0.036	0.032	0.014	6.515	2.252	1.005	0.109	0.085	0.038	0.24	0.19	0.051
14	City of Galena, KS	7-17-83 to 11-26-83	20	0.020	0.020	0.006	0.039	0.026	0.014	1.679	1.330	0.582	0.359	0.345	0.082	0.900	0.890	0.312
15	South of Galena, KS	7-23-83 to 11-26-83	15	0.030	0.030	0.012	0.047	0.045	0.033	2.435	2.122	0.836	0.044	0.044	0.021	1.610	1.370	0.698
--	Columbus, KS	7-17-83 to 11-26-83	22	0.030	0.030	0.010	0.049	0.049	0.023	2.657	1.791	0.731	0.055	0.042	0.021	1.240	1.110	0.222

[a] Highest level reported in the data set.
[b] Second highest level reported in the data set.

Table V-3
(Continued)

Map No.	Site	Date	No. of Observations	Nickel			Arsenic			Barium			Ref
				1st[a]	2nd[b]	Avg	1st	2nd	Avg	1st	2nd	Avg	
20	Galena, KS	5-6-75 to 5-30-75	5	0.019	0.018	0.013		NA			NA		23
--	Picher, OK (Analysis on TSP)	8-23-82 to 11-11-82	7	2.70	2.13	0.69	<0.004	<0.004	<0.004	3.24	1.67	1.63	24
--	Analysis on Respirable (10 micron) Particulates	8-23-82 to 11-11-82	7	1.86	0.50	0.34	<0.004	<0.004	<0.004	4..97	3.17	2.42	24
--	West of Treece, KS (TSP)	7-17-83 to 11-26-83	15	0.50	0.42	0.149	0.006	0.000	0.000	0.986	0.099	0.096	11
--	West of Treece, KS (inhalable particulate)	7-18-83 to 11-26-83	20	0.820	0.690	0.196	0.005	0.000	0.000	0.563	0.250	0.052	11
--	Treece, KS (TSP)	7-17-83 to 11-26-83	21	1.18	0.95	0.29	0.006	0.001	0.000	1.275	0.218	0.102	11
--	Treece, KS (inhalable particulate)	8-23-83 to 11-20-83	11	1.16	0.990	0.404	0.000	0.000	0.000	0.100	0.09	0.032	11
--	Baxter Springs, KS	7-17-83 to 11-26-83	23	0.24	0.19	0.051	0.007	0.000	0.000	1.218	0.582	0.111	11
14	City of Galena, KS	7-17-83 to 11-26-83	20	0.900	0.890	0.312	0.004	0.002	0.001	0.933	0.128	0.089	11
15	South of Galena, KS	7-23-83 to 11-26-83	15	1.610	1.370	0.498	0.004	0.000	0.000	0.751	0.125	0.086	11
--	Columbus, KS	7-17-83 to 11-26-83	22	1.240	1.110	0.222	0.006	0.000	0.000	1.274	1.052	0.129	11

[a]Highest level reported in the data set.

[b]Second highest level reported in the data set.

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quality in the Cherokee County area is generally comparable to air quality in typical non-urban or urban areas of the United States.

D. RESPIRABLE AND SETTLEABLE PARTICULATES

Respirable particulate data in the Cherokee County area has been reported only from Picher, Oklahoma, by the Tar Creek Task Force and from two locations at Treece, Kansas, by the KDHE (Table V-4). Dustfall data, reported as Settleable Particulates, are also fairly limited (Table V-5). These limited data indicate that air quality for these parameters are generally within acceptable levels.

E. SULFUR DIOXIDE

Sulfur dioxide (SO2) and sulfation rate data were available only from Irwin's (1971) study near Galena. Sulfur dioxide concentrations from the single sampling location ranged from less than 1 mg/m to 31 mg/m. All concentrations were considerable below the 365 mg/m 24-hour NAAQS standard (Table V-6). Sulfation plates exposed at the Bennett and Wood farms in March 1971 collected 1.15 and 1.05 mg/m/CU/day.

Table V-4
RESPIRABLE PARTICULATE ANALYSES

Sample Location	Date	Number of Observations	24-Hour Maximum ($\mu g/m^3$)	24-Hour Second Highest ($\mu g/m^3$)	Reference
Picher, OK	9-23-82 to 10-14-82	8	43[a]	39[a]	24
West of Treece, KS	7-18-83 to 11-26-83	20	63[b]	62[b]	11
Treece, KS	8-23-83 to 11-20-83	11	205[b]	80[b]	11

[a] Less than 10 microns.

[b] Less than 15 microns.

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Table V-5
SUMMARY OF SETTLEABLE PARTICULATE ANALYSES

Map No.	Sample Location	Date	Duration	Concentration (tons/mi²/month)	Comments	REF
2	Wood's Farm	Mar-Apr 1971	~90 days	9.75	Downwind of active smelter	7
1	Bennett's Farm	Mar-Apr 1971	~90 days	9.61	Downwind of active smelter	7
6N	Galena	2-8-73 to 5-25-73	106 days	81.2		23
6S	Galena	2-8-73 to 5-25-73	106 days	75.9		23
7E	Galena	2-8-73 to 5-25-73	106 days	150.4		23
7W	Galena	2-8-73 to 5-25-73	106 days	102.9		23
7	Galena	2-8-73 to 5-25-73	106 days	59.3		23
8E	Galena	2-8-73 to 5-25-73	106 days	125.0		23
8W	Galena	2-8-73 to 5-25-73	106 days	89.7		23
9	Galena	2-8-73 to 5-25-73	106 days	29.7		23

Table V-6
SULFUR DIOXIDE (SO_2) AND SULFATION DATA SUMMARY

Site	Date	No. of Observations	24-Hour NAAQS Primary Standard (365 µg/m)[1] No. of Exceedances	% Exceedance	High	Second High
Larry's Field Galena, KS	Apr 12-29 1971	18	0	0	31	26

Site	Date	No. of Observations	Sulfation Concentrations SO_3 (µg/m³/CU²day)
Bennett's Farm	3-26-71 to 3-30-71	1	1.15
Wood's Farm	3-26-71 to 3-30-71	1	1.05

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VI. SOIL DATA

A. INTRODUCTION

An evaluation of general soil and chat pile conditions in the Galena, Kansas area is primarily based on results from soil profile samples collected in 1971 in agricultural areas downwind of the active smelter at Galena and on soil profile and chat samples collected in 1973 after the smelter had ceased operating. The 1973 samples were collected from tailings piles, soil downwind of the tailings, soil adjacent to chat-paved roads, and soil downwind of the formerly active smelter. Also considered were results of sampling performed at two tailings piles in 1983.

According to Lagerwerff et. al. (1972) and meteorological data provided by Irwin (1971), wind direction in the Galena area is generally out of the south or southwest. Therefore, contamination due to airborne material is likely to occur to a greater extent in areas north and northeast of the source. As a result, most of the soil data was collected in areas north and northeast of the Galena smelter. The smelter is located just north of Galena adjacent to Short Creek.

The available soil data for the Galena, Kansas area are summarized in Table VI-1. At some sampling locations, multiple and varying samples were taken. Some of the data were evaluated in relation to concentrations observed in representative background samples collected at locations free from the influence of the smelter. Samples with no comparable background data were assessed relative to the soil criteria discussed in Section II. Exceedences of both the background concentrations and the soil criteria in Section II are contained in Table VI-1. The sampling locations in relation to the smelter are shown on Drawing 84265-M3.

B. DATA COLLECTED PRIOR TO SMELTER CLOSURE

Results of soil sampling conducted in 1971 and reported by Irwin (1971) for Sample Locations 1 through 6, and Largerwerff et al. (1972) for Sample Locations 7 through 12 could not be directly compared due to the different extraction methods utilized by the authors in determining constituent concentrations within the soil. However, both authors results indicated that concentrations of lead, zinc, cadmium and copper generally decreased with increasing distance from the smelter. Analyses of soil profiles reported by both authors showed that metal concentrations were significantly higher at the surface than at depth.

Assessment of the degree of contamination in soils downwind of the smelter was aided by the availability of several background samples collected in 1971 at Locations 10, 11, and 12, and reported by Lagerwerff et. al. (1972). These background soil samples were collected in areas downwind but "protected" from the influence of the active smelter (i.e. beneath houses). As a result constituent concentrations in these samples were used as a means

TABLE VI-1

SUMMARY OF SOIL AND CHAT SAMPLES EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Date	Sample Depth	Reference No.	Observed Concentrations (ppm by wt) Pb	Zn	Mn	Cd	Cu	Total Exceedances	No. of Analyses
1	Bennett Farm, North of Galena Downwind of Active Smelter	Soil Profile	3/24/71	Surface 6 in.	7 Irwin (1971)	170 0	950* 32	NA NA	15* 1	NA NA	2	6
2	Bennett Farm, North of Galena Downwind of Active Smelter	Soil Profile	3/24/71	Surface 6 in. 12 in.	7	60 30 0	680* 130 38	NA NA NA	10* 5 0	NA NA NA	2	9
3	Bennett Farm, North of Galena Downwind of Active Smelter	Soil Profile	3/24/71	Surface 6 in.	7	180 0	660* 36	NA NA	11* 0	NA NA	2	6
4	Mallatt Farm, North of Galena Downwind of Active Smelter	Soil Profile	3/24/71	Surface 6 in. 12 in.	7	80 10 10	730* 56 32	NA NA NA	11* 0 0	NA NA NA	2	9
5	Wood Farm, Northeast of Galena, Downwind of Active Smelter	Soil Profile	3/24/71	Surface 6 in.	7	120 20	440* 110	NA NA	10* 1	NA NA	2	6
6	L. Fields Farm Northeast of Galena, Downwind of Active Smelter	Soil Profile	3/24/71	Surface 8 in.	7	1100* 60	6300* 450*	NA NA	110* 5	NA NA	4	6
7	Northeast of Galena, Approx. 330 meters downwind of Active Smelter	Soil Profile	8/71	0-5 cm 5-10 cm 10-20 cm	15	1600# 1000# 256	15600# 4360# 3600#	NA NA NA	102# 48# 22#	70# 11# 10#	11	12

* Exceeds relative criteria presented in Section II

\# Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1972)

° Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1975)

NA Not analyzed

TABLE VI-1 (con't)

SUMMARY OF SOIL AND CHAT SAMPLES EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Date	Sample Depth	Reference No.	Observed Concentrations (ppm by wt) Pb	Zn	Mn	Cd	Cu	Total Exceedances	No. of Analyses
8	Northeast of Galena, Approx. 1000 meters downwind of Active Smelter	Soil Profile	8/71	0-5 cm	15 Lagerwerff (1972) & Brower & Biersdorf	960#	3100#	NA	32.6#	14.4#	8	12
				5-10 cm		88	680#	NA	12.2#	4.0		
				10-20 cm		34	420#	NA	3.1#	4.0		
9	Northeast of Galena, Approx. 1670 meters downwind of Active Smelter	Soil Profile	8/71	0-5 cm	15	428#	2480#	NA	26.8#	6.2#	6	12
				5-10 cm		52	420#	NA	7.2#	2.4		
				10-20 cm		29	280	NA	1.2	3.4		
10	North of Galena Approx. 2170 meters downwind of Active Smelter	Protected (Unconta-minated Soil Profile	8/71	0-5 cm	15	190	270	138	1.1	3.5		
				5-10 cm		166	300	111	1.3	3.5		
				10-20 cm		118	288	82	1.3	3.2		
		Unprotected (Contaminated Soil Profile	8/71	0-5 cm		463#	2690#	252#	14.4#	9.2#	14	15
				5-10 cm		280#	1890#	234#	10.5#	6.7#		
				10-20 cm		247	1130#	177#	10.8#	6.5#		
11	North of Galena Approx. 1330 meters downwind of Active Smelter	Protected (Unconta-minated Soil Profile	8/71	0-5 cm	15	262	336	120	3.0	1.3		
				5-10 cm		128	300	81	1.3	1.1		
				10-20 cm		98	300	87	1.3	1.1		
		Unprotected (Contaminated Soil Profile	8/71	0-5 cm	15	640#	2215#	284#	23.0#	8.8#	11	15
				5-10 cm		276#	1210#	180#	14.0#	2.1		
				10-20 cm		128	750#	111	4.5#	1.7		

* Exceeds relative criteria presented in Section II

\# Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1972)

° Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1975)

NA Not analyzed

TABLE VI-1 (con't)

SUMMARY OF SOIL AND CHAT SAMPLES EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Date	Sample Depth	Reference No.	Observed Concentrations (ppm by wt) Pb	Zn	Mn	Cd	Cu	Total Exceedances	No. of Analyses
12	Northeast of Galena, Approx. 2000 meters downwind of Active Smelter	Protected (Unconta-minated Soil Profile	8/71	0-5 cm	15	51.5	336	142	2.9	4.4		
				5-10 cm		77.1	396	120	2.4	5.0		
				10-20 cm		41.4	316	98	1.9	3.3		
		Unprotected (Contaminated Soil Profile	8/71	0-5 cm	15	255	1860#	348#	16.4#	19.4#	11	15
				5-10 cm		168	900#	234#	7.5#	12.4#		
				10-20 cm		75	570#	120	4.0#	7.4#		
13	Tailing pile Northwest of Galena	Chat	1973	0-60 cm	17 Lagerwerff & Brower (1975)	91	247	NA	0.66	NA	6	12
	33 Meters Downwind of Tailing pile	Topsoil		0-5 cm	17	225	1760°	NA	10.6°	NA		
	67 Meters Downwind of Tailing pile	Topsoil		0-5 cm	17	211	1400°	NA	11.0°	NA		
	167 Meters Downwind of Tailing pile	Topsoil		0-5 cm	17	292	1160°	NA	18.6°	NA		
14	Tailing pile West-South West of Galena	Chat	1973	0-60 cm	17	196	127	NA	0.15	NA	0	12
	33 Meters Downwind of Tailing pile	Topsoil		0-5 cm	17	39.0	425	NA	5.4	NA		
	67 Meters Downwind of Tailing pile	Topsoil		0-5 cm	17	56.0	473	NA	4.4	NA		
	167 Meters Downwind of Tailing pile	Topsoil		0-5 cm	17	73.4	573	NA	5.0	NA		

* Exceeds relative criteria presented in Section II

\# Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1972)

° Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1975)

NA Not analyzed

TABLE VI-1 (con't)

SUMMARY OF SOIL AND CHAT SAMPLES EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Date	Sample Depth	Reference No.	Observed Concentrations (ppm by wt) Pb	Zn	Mn	Cd	Cu	Total Exceedances	No. of Analyses
15	Point on chat-covered road approx. 5500 ft. east of Shawnee; 8 meters from road on north transect	Soil Profile	1973	0-5 cm	17	138	3110°	NA	14.8°	NA	3	54
				5-10 cm		42.2	407	NA	2.26	NA		
				10-15 cm		44.0	356	NA	2.8	NA		
	17 Meters from road North Transect	Soil Profile	1973	0-5 cm	17	56.0	1128°	NA	5.84	NA		
				5-10 cm		33.6	193	NA	1.58	NA		
				10-15 cm		30.2	160	NA	1.32	NA		
	33 Meters from road North Transect	Soil Profile	1973	0-5 cm	17	53.2	908	NA	4.92	NA		
				5-10 cm		40.0	153	NA	1.06	NA		
				10-15 cm		21.4	110	NA	1.00	NA		
	8 Meters from road South Transect	Soil Profile	1973	0-5 cm	17	42.8	311	NA	2.92	NA		
				5-10 cm		34.0	197	NA	1.50	NA		
				10-15 cm		17.8	113	NA	0.60	NA		
15	17 Meters from road South Transect	Soil Profile	1973	0-5 cm	17	21.8	116	NA	1.10	NA		
				5-10 cm		21.0	93	NA	0.88	NA		
				10-15 cm		19.6	110	NA	0.96	NA		
	33 Meters from road South Transect	Soil Profile	1973	0-5 cm	17	21.4	102	NA	1.14	NA		
				5-10 cm		26.0	116	NA	1.02	NA		
				10-15 cm		21.4	104	NA	0.88	NA		

* Exceeds relative criteria presented in Section II

Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1972)

° Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1975)

NA Not analyzed

TABLE VI-1 (con't)

SUMMARY OF SOIL AND CHAT SAMPLES EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Date	Sample Depth	Reference No.	Observed Concentrations (ppm by wt) Pb	Zn	Mn	Cd	Cu	Total Exceedances	No. of Analyses
16	Point on chat-covered road approx. 6500 ft. west of Galena; 8 meters from road on north transect	Soil Profile	1973	0-5 cm	17	218	2010°	NA	13.3°	NA	10	54
				5-10 cm	17	109	397	NA	6.24	NA		
				10-15 cm		35.4	323	NA	6.66	NA		
	17 Meters from road North Transect	Soil Profile	1973	0-5 cm	17	172	1030°	NA	10.3°	NA		
				5-10 cm		66.5	342	NA	4.06	NA		
				10-15 cm		32.0	395	NA	3.77	NA		
	33 Meters from road North Transect	Soil Profile	1973	0-5 cm	17	153	990°	NA	11.4°	NA		
				5-10 cm		71.1	385	NA	4.53	NA		
				10-15 cm		34.0	350	NA	4.47	NA		
	8 Meters from road South Transect	Soil Profile	1973	0-5 cm	17	220	1552°	NA	11.4°	NA		
				5-10 cm		143	667	NA	4.98	NA		
				10-15 cm		168	529	NA	5.34	NA		
	17 Meters from road South Transect	Soil Profile	1973	0-5 cm	17	185	1040°	NA	10.9°	NA		
				5-10 cm		177	569	NA	4.06	NA		
				10-15 cm		172	630	NA	4.15	NA		
	33 Meters from road South Transect	Soil Profile	1973	0-5 cm	17	181	859	NA	8.00	NA		
				5-10 cm		184	512	NA	4.61	NA		
				10-15 cm		176	562	NA	4.25	NA		
17	Approx. 5000 ft. N-NE of Galena	Topsoil	1973	0-5 cm	17	742°	7500°	NA	30.0°	NA	3	3
18	Tailing Pile just NE of Galena	Chat	1973	Composite	17	9120°	3135	NA	13.6°	NA	3	3

* Exceeds relative criteria presented in Section II

\# Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1972)

° Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1975)

NA Not analyzed

TABLE VI-1 (con't)

SUMMARY OF SOIL AND CHAT SAMPLES EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Date	Sample Depth	Reference No.	Observed Concentrations (ppm by wt) Pb	Zn	Mn	Cd	Cu	Total Exceedances	No. of Analyses
10	North of Galena Approx. 2170 meters downwind of formerly active smelter	Protected Topsoil	1973	0-5 cm	17	325	710	NA	4.0	NA		
		Unprotected Topsoil	1973	0-5 cm	17	750°	2900°	NA	20.5°	NA	3	3
11	North of Galena Approx. 1330 meters downwind of formerly active smelter	Protected Topsoil	1973	0-5 cm	17	221	930	NA	6.5	NA		
		Unprotected Topsoil	1973	0-5 cm	17	503°	6150°	NA	60°	NA	3	3
12	North of Galena Approx. 2000 meters downwind of formerly active smelter	Protected Topsoil	1973	0-5 cm	17	183	730	NA	8.0	NA		
		Unprotected Topsoil	1973	0-5 cm	17	375°	2180°	NA	18.7°	NA	3	3
13	Tailing pile Northwest of Galena	Chat	1973	Composite	17	1437°	3825°	NA	18.8°	NA	3	3

* Exceeds relative criteria presented in Section II

\# Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1972)

° Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1975)

NA Not analyzed

TABLE VI-1 (con't)

SUMMARY OF SOIL AND CHAT SAMPLES EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Date	Sample Depth	Reference No.	Observed Concentrations (ppm by wt) Pb	Zn	Mn	Cd	Cu	Total Exceedances	No. of Analyses
14	Tailing pile WSW of Galena	Chat	1973	Composite	17	1500°502		NA	2.3	NA	1	3
19	Tailing pile just North of Galena	Chat	5/18/83	Composite	12	720*	1360*	32	18*	47	3	5
20	Tailing pile WNW of Galena	Chat	5/18/83	Composite	12	410*	3940*	99	11*	28	3	5

* Exceeds relative criteria presented in Section II
\# Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1972)
° Exceeds maximum concentrations observed in background samples collected at Stations 10,11, and 12 and reported by Lagerwerff et. al. (1975)
NA Not analyzed

of comparison when assessing other samples collected at the same time. Samples were also taken from unprotected points at Locations 10, 11 and 12. Soil samples collected in "unprotected areas" were shown to have concentrations on the average 2.3 times more for lead, 4.8 times more for zinc, 2.0 times more for manganese, and 7.0 times more for cadmium, than adjacent protected areas. Soil samples from exposed areas located between 330 and 1670 meters downwind of the smelter at Locations 7, 8, and 9 also had much higher concentrations of these metals than the background samples from the protected areas at Locations 10, 11, and 12.

In general, results of the soil sampling conducted prior to smelter closure indicate that the smelter was the probable source of the elevated contaminant levels observed in downwind soil and that the contaminants were likely transmitted through the air. Due to the influence of the smelter, which is now inactive, the data cannot be considered representative of present chemical characteristics of the area soil. However, it is valuable in establishing a historical baseline to compare subsequent analyses.

C. DATA COLLECTED FOLLOWING SMELTER CLOSURE

Soil sampling conducted again in 1973 at Locations 10 through 16 and reported by Lagerwerff and Brower (1975) showed that metals concentrations in the Galena area soils decreased with depth, reinforcing the notion that contaminants were deposited aerially. Background soil sample results were once again provided for Locations 10, 11, and 12 in areas downwind and protected from the influence of the previously active smelter.

Constituent concentrations in soils from both the "protected" and "unprotected" areas at Locations 10, 11, and 12 were generally much higher than concentrations reported for the 1971 samples at these same locations. Despite this difference, concentrations in soil from the adjacent "unprotected areas" were on the average 2.2, 4.6, and 5.9 times more for lead, zinc, and cadmium, respectively, than concentrations observed in the protected areas.

Results of soil sampling downwind of two tailing piles conducted in 1973 at Locations 13 and 14 and reported by Lagerwerff and Brower (1975) appeared to show that there is little or no migration of potentially contaminated dust from the tailings. This conclusion is based on the lack of a gradient in metal concentrations with increasing distance from the piles and on the reported observation that only the top layer of the tailing pile showed sufficient weathering to produce the dust-sized particles which could be removed by wind action. It is also based on the fact that metal concentrations in the tailings were observed to be lower than those in downwind soil.

Results of soil samples obtained at increasing distances from two roads paved with chat, at Locations 15 and 16, suggested that contamination of the

soil had occurred close to the roads via fugitive dust deposition. This was attributed to the breakdown and disturbance of chat. However, soil contamination by this mode, though detectable, is probably limited to a few hundred feet of the road (Reference 17).

D. EVALUATION

In general, results of soil sampling indicate elevated concentrations of heavy metals in several areas near the Galena smelter. These results also suggest that the contaminants were transmitted to the soil via airborne pollution from the smelter. Although the primary source of airborne contaminants was removed with the closure of the smelter in 1971, levels of contaminants in soil samples taken in this area prior to and two years after smelter closure indicate the concentration of lead, zinc, and cadmium in downwind soils decreased little, if any, over the period following smelter closure. Additional soil sampling appears to be warranted in the area downwind of the smelter to confirm whether the elevated concentrations still persist.

Fugitive dust from roads surfaced with chat may be a possible source of soil contamination. Based on very limited sampling, tailing piles were shown to be an unlikely source of soil contamination. The data also indicated that metal concentrations within the tailing piles were quite variable possibly due to secondary recovery of metal.

VII. SEDIMENT

No sediment data were available from the existing data base for either streams or lakes in the Galena, Kansas area. In theory, stream or lake sediments may function as a sink for water-borne contaminants and subsequently a source of contaminant release to water. The most direct effects of contaminated sediments occur through physical or chemical influences upon bottom dwelling aquatic organics and sensitive fish species. Bioaccumulation of heavy metals in fish or other aquatic organisms may occur in streams or lakes containing contaminated sediments. If these organisms are used as a supplementary human food source, a potential for human health effects may occur. It is therefore considered appropriate to investigate the chemical content of sediments from areas where deposition is likely to occur. Also, the potential of bioaccumulation by edible aquatic organisms should be investigated to estimate potential public health hazards.

VIII. BIOLOGICAL DATA

A. INTRODUCTION

The available data base for the Galena area contains results of aquatic macroinvertebrate sampling, analyses of home grown produce, analyses of milk, and analyses of animal and human blood and human hair.

Aquatic macroinvertebrate sampling and analysis can be used to reflect the net long term effects of exposure to aggregate pollution sources. Interpretation of the result of aquatic macroivertebrate sampling is complicated by differences in physical stream conditions which may override subtle chemically induced changes in species composition.

With the exception of aquatic macroinvertebrate samples, the biological data were collected to investigate possible influences of emissions from the smelter at Galena. These biological data can provide insight into the net result of exposure at various points in the food chain to aggregate pollution sources via all environmental media.

In human terms, analyses of consumable products (e.g. vegetables, milk) provide information on the potential for transfer of contaminants from soil, water and air through these food sources. Analyses of human blood and hair reflect the aggregate net effects of long term exposure to pollution from all sources and environmental media.

With the exception of the aquatic macroinvertebrate data, in-depth analysis of the biological data obtained is more appropriately performed as part of an endangerment or exposure assessment. As such, evaluation of these biological data will only be performed as it applies to development of a work plan for the Galena area.

B. STREAM BIOLOGICAL DATA

1. Data: Evaluation of biological conditions in the area is based on results from biological sampling conducted at five stations located on Spring River and its tributaries, Short Creek and Shoal Creek, in the fall of 1978 and spring of 1979. In this study, the relative numbers and diversity of the benthic invertebrate population was used to assess the water quality of Spring River and its tributaries. The study primarily assessed influences of decomposable organic matter (i.e., municipal waste water discharges, etc.) on water quality, but the influences of acid mine drainage and heavy metal contamination were also reflected in the sampling results. A summary of macroinvertebrate tolerance to pollution for stream stations in the Galena, Kansas area is presented in Table VIII-1. Sampling locations are shown on Drawing 84265-M1.

TABLE VIII-1

MACROINVERTEBRATE TAXA TOLERANCE TO DECOMPOSABLE ORGANIC POLLUTION FOR SELECTED STREAM STATIONS IN THE GALENA, KANSAS AREA DURING FALL OF 1978 AND SPRING OF 1979

Base Map Identification Number	Location/ Description	Period of Record	Number of Observations	Total Taxa	Mayfly Taxa	% Clean Water Taxa	% T	% F	% I
1	Spring River, approx. 3-1/2 miles north of Galena and downstream of confluence with Center Creek and upstream of confluence with Turkey Creek	Oct-Nov, 1978	1	32	6	41	12(4)	41(13)	22(7)
		May, 1979	1	38	9	52	11(4)	32(12)	34(13)
2	Spring River above confluence with Short Creek	May, 1979	1	22	4	36	18(4)	41 (9)	18(4)
3	Short Creek, northwest of Galena and upstream of confluence with Spring River	Oct-Nov, 1978	1	7	0	43	29(2)	14 (1)	29(2)
		May, 1979	1	4	0	50	50(2)	0	25(1)
4	Shoal Creek, approx. 1 mile south of Galena and upstream of Riverton Impoundment	Oct-Nov, 1978	1	20	1	35	15(3)	59(10)	25(5)
		May, 1979	1	28	3	43	7(2)	39(11)	25(7)
5	Spring River, just downstream of Riverton Impoundment	Oct-Nov, 1978	1	15	0	53	7(1)	33 (5)	33(5)

T Tolerant
F Facultative
I Intolerant
() Actual Number of Taxa
Source: Reference Number 14

2. Evaluation: Biological sampling of Spring River indicated that there was no significant reduction in total taxa, pollution sensitive groups, or changes in species composition from station 1, located above Spring River's confluence with Turkey Creek, to station 2, just above the confluence of Short Creek with the Spring River. Therefore, any pollutant contributions from point and non-point discharges between these two stations did not appear to make a significant impact on stream biota in the upper Spring River.

   The biota in the lower reaches of Spring River were shown to be stressed based on the low taxa values and the absence of several pollution sensitive groups as shown in the results from Station 5. Much of the stress on biota was no doubt due to the contribution of contaminants from Spring River's tributary, Short Creek, which exhibits toxic heavy metals contamination. This condition was reflected in Short Creek at Station 3 by the low taxa numbers and complete absence of pollution-sensitive mayfly-stonefly groups in benthic samples. The biota at Station 4 in Shoal Creek, which also flows into the Spring River, was not found to be noticeably stressed.

   In general, the results of the biological sampling agree with the results obtained during surface water sampling. As a general evaluation, the results are useful in characterizing the general degree of induced stress on the benthic invertebrate community within Spring River and its tributaries, but are of little help in assessing the site-specific effects from the lead and zinc mined areas.

C. VEGETATION AND HOME PRODUCE DATA

1. Data: Most of the vegetation and home produce samples were collected in downwind locations during the operation of the Galena Smelter. The samples include various grasses, commercial crops and frozen produce from the freezers of area residents. A range of metal concentrations found to occur naturally in plants and the heavy metal content of freezer produce purchased in suburban Washington D.C. were used as a basis of comparison and are presented in Section II. Relative exceedences of the available vegetation data above typical concentrations are summarized in Table VIII-2. The sampling locations are shown on Drawing 84265-M4.

   Data from pasture grass samples collected on farms downwind of the smelter in 1971 (Locations 1 through 6) and reported by Irwin (1971) indicate relative heavy metal contamination. As shown in Table VIII-2, concentrations of lead, zinc, and cadmium were noted to be significantly high when compared to the relative criteria presented in Section II. Data from Irwin (1971) also show that hay grown and baled downwind of the smelter had substantially higher metal concentrations than hay grown outside the smelter influence.

TABLE VIII-2

SUMMARY OF SELECTED VEGETATION AND HOME PRODUCE SAMPLES
EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Period of Record	Reference Number	Concentrations in Exceedance of Metal Concentrations Typically Found in Plants (ppm by wt.) Pb	Zn	Cd	Cu	Total Exceedances	Number of Analyses
1	Bennett Farm, North of Galena Downwind of Active Smelter	Green Grass[1]	3/24/71	7	80	1800	28	NA	12	12
		Green Grass[2]			60	1600	22	NA		
		Dry Grass[1]			120	2700	36	NA		
		Dry Grass[2]			160	3000	35	NA		
2	Bennett Farm, North of Galena Downwind of Active Smelter	Green Grass[1]	3/24/71	7	80	2200	30	NA	12	12
		Green Grass[2]			100	2100	30	NA		
		Dry Grass[1]			100	2200	30	NA		
		Dry Grass[2]			100	2000	28	NA		
3	Bennett Farm, North of Galena Downwind of Active Smelter	Green Grass[1]	3/24/71	7	60	2000	28	NA	12	12
		Green Grass[2]			100	1800	25	NA		
		Dry Grass[1]			140	2100	30	NA		
		Dry Grass[2]			160	1800	30	NA		
4	Mallatt Farm, North of Galena Downwind of Active Smelter	Green Grass[1]	3/24/71	7	40	1400	18	NA	12	12
		Green Grass[2]			60	1300	16	NA		
		Dry Grass[1]			100	1600	25	NA		
		Dry Grass[2]			160	1600	28	NA		
5	Wood Farm, Northeast of Galena, Downwind of Active Smelter	Green Grass[1]	3/24/71	7	40	2200	16	NA	12	12
		Green Grass[2]			80	3000	22	NA		
		Dry Grass[1]			140	2100	45	NA		
		Dry Grass[2]			140	2100	45	NA		
6	L. Fields Farm Northeast of Galena, Downwind of Active Smelter	Short Grass[1]	3/24/71	7	220	2800	41	NA	12	12
		Dry Grass[2]			220	3400	52	NA		
		Tall Grass[1]			220	2900	50	NA		
		Dry Grass[2]			220	3400	52	NA		

NA Not Analyzed

1 Analysis of sample involved leaching of intact sample with nitric acid to determine amount of contaminants deposited on surface

2 Analysis of sample involved ashing sample prior to leaching with nitric acid to determine amount of contaminants deposited on surface and absorbed within plant tissue.

TABLE VIII-2 (con't)

SUMMARY OF SELECTED VEGETATION AND HOME PRODUCE SAMPLES
EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Period of Record	Reference Number	Concentrations in Exceedance of Metal Concentrations Typically Found in Plants (ppm by wt.) Pb	Zn	Cd	Cu	Total Exceedances	Number of Analyses
None	Hay Grown and Baled on Bennetts Farm	Dry Grass[1] Dry Grass[2]	3/24/71	7	20 40	650 650	8 5	NA NA	6	6
None	Bennett's Purchased Hay Grown and Baled at Baxter Springs	Dry Grass[1] Dry Grass[2]	3/24/71	7	— —	44 44	1 1	NA NA	4	6
7	Northeast of Galena, Approx. 2400 meters downwind of Active Smelter	Grass	8/71	15	16.2	250	1.4	25.3	4	4
8	Northeast of Galena, Approx. 2000 meters downwind of Active Smelter	Grass	8/71	15	21.5	335	3.0	31.5	4	4
9	Northeast of Galena, Approx. 1000 meters downwind of Active Smelter	Grass	8/71	15	55.0	486	5.7	139	4	4
10	Northeast of Galena, Approx. 670 meters downwind of Active Smelter	Grass	8/71	15	74.4	592	6.9	231	4	4
11	Northeast of Galena, Approx. 330 meters downwind of Active Smelter	Grass	8/71	15	98.4	658	8.6	327	4	4

— Did not exceed relative criteria presented in Section II
NA Not Analyzed
1 Analysis of sample involved leaching of intact sample with nitric acid to determine amount of contaminants deposited on surface
2 Analysis of sample involved ashing sample prior to leaching with nitric acid to determine amount of contaminants deposited on surface and absorbed within plant tissue

TABLE VIII-2 (con't)

SUMMARY OF SELECTED VEGETATION AND HOME PRODUCE SAMPLES
EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Period of Record	Reference Number	Concentrations in Exceedance of Metal Concentrations Typically Found in Plants (ppm by wt.) Pb	Zn	Cd	Cu	Total Exceedances	Number of Analyses
12	North of Galena Approx. 330 meters upwind of Active Smelter	Grass	8/71	15	87.0	500	5.7	214	4	4
13	North of Galena Approx. 670 meters upwind of Active Smelter	Grass	8/71	15	65.6	354	5.0	175	4	4
14	North of Galena Approx. 1000 meters upwind of Active Smelter	Grass	8/71	15	49.2	282	2.8	110	4	4
15	City of Galena Approx. 1670 meters upwind of Active Smelter	Grass	8/71	15	25.0	200	—	32.8	3	4
16	North of Galena Approx. 1830 meters downwind of Active Smelter	Sorghum Stems Sorghum Leaves Sorghum Seeds	10/71	15	36.0 70.0 28.0	21 111 22	4.7 5.4 1.6	— 44.4 25.6	11	12
17	Northeast of Galena, Approx. 2000 meters down-wind of Active Smelter	Soybean Stems Soybean Leaves Soybean Pods	10/71	15	18.0 52.0 32.0	19 109 —	2.9 5.8 1.0	— -- --	8	12

— Did not exceed relative criteria presented in Section II

TABLE VIII-2 (con't)

SUMMARY OF SELECTED VEGETATION AND HOME PRODUCE SAMPLES
EXCEEDING RELATIVE CRITERIA
GALENA, KANSAS AREA

Map No.	Sample Location	Sample Type	Period of Record	Reference Number	Concentrations in Exceedance of Metal Concentrations Typically Found in Plants (ppm by wt.) Pb	Zn	Cd	Cu	Total Exceedances	Number of Analyses
18	Northeast of Galena, Approx. 1700 meters downwind of Active Smelter Samples 170 M Apart	Alfalfa	10/71	15	25.6	29	2.5	20.0	6	8
		Alfalfa			16.2	22	2.5	34.0		
None	All Produce Samples were Collected from Freezers of Individuals Living in Area Within 2 km Downwind of Smelter. This Area was Considered Area of "High Exposure." All Produce Samples were Grown and Frozen Prior to 9/71 when Smelter Ceased Operations	Bean	1971	16	14.0	71.2	0.73	NA	3*	3
		Carrot	1971		14.3	189	8.0	NA	3	3
		Lettuce	1971		18.9	197	3.8	NA	3	3
		Pea	1971		19.5	99.7	0.70	NA	3	3
		Potato	1971		14.1	71.7	1.9	NA	3	3
		Tomato	1971		28.0	86.5	1.8	NA	3	3
		Rhubarb	1971		31.5	130	2.6	NA	3	3

* Produce results compared with heavy metal content of freezer produce purchased in Washington, DC 1971-1972, reported by Lagerwerff and Brower (1974) and presented in Section II.

NA Not Analyzed

Concentrations of certain heavy metals in the grasses and commercial crops collected by Lagerwerff et. al. (1972) were generally observed to be high for lead, zinc, cadmium and copper when compared to the relative criteria presented in Section II. Grass samples obtained at varying distances upwind of the smelter (Locations 12 through 15) were generally noted to be lower in metals than samples taken comparable distances downwind (Locations 9 through 11). In general, metal concentrations in the grass, as in the soils, were observed to decrease with increasing distance form the smelter.

Data from samples collected in 1971 (Locations 7 through 18) and reported by Lagerwerff et. al. (1972) were not directly comparable to data collected by Irwin (1971) due to differences in analytical methods by the two authors. In addition, the grass samples were collected after smelter operations involving cadmium and lead had been discontinued whereas Irwin's data had been collected when the smelter was in full operation.

Samples of frozen produce grown downwind of the smelter prior to its closure and reported by Lagerwerff and Brower (1974) exhibited substantially higher metal concentrations than those observed in comparable produce purchased in Washington, DC as part of the study.

2. Evaluation: The presence of heavy metals in the vegetation near the Galena smelter is likely due to the direct deposition of airborne contaminants on plants or the transfer of contaminants to the plant from the soil. Relative contamination of plants via both pathways was occurring, although smelter operations had been cut back at the time of the 1971 sampling reported by Lagerwerff et. al. (1972). With the closure of the smelter in the fall of 1971, the primary source of airborne contaminants had been eliminated. Therefore, any subsequent elevated levels of contaminants in vegetation could likely be attributed to the transfer of residential contaminants from the soil. According to the authors, the relatively high metal concentrations observed in grasses sampled in August of 1971 (Locations 7 through 15) had accumulated in the vegetation primarily by uptake from the roots. This opinion was based on the fact that the smelter had already ceased operations.

Due to the considerable amount of time since sampling, the data summarized in this section may not reflect present conditions within the Galena smelter area. However, available soil data indicate the persistence of some metals considered potentially hazardous to human health. Because these metals may be transferred to vegetation or crops consumed by humans, or animals for food for humans, additional soil sampling should be conducted in the area downwind of the smelter to determine if these high metal concentrations still exist.

D. MILK DATA

1. Data: Evaluation of the effect of elevated metal accumulations in soil and vegetation on milk from cows grazing downwind from the Galena smelter is based on results from milk sampling conducted after smelter closure in May of 1972 and January of 1973 (Lagerwerff and Brower, 1974). Specimens were gathered less than 2 km (high exposure area) or more than 3 km (low exposure area) downwind from the smelter. The authors had identified the former area as a high exposure area based on its steep soil concentration gradients for cadmium, lead, and zinc observed in an earlier investigation. A range of metal concentrations found in U.S. milk and cited in literature were used as a basis of comparison and are presented in Section II. Exceedences of these concentrations in available data are summarized in Table VIII-3.

   In general, higher milk lead concentrations were observed during springtime grazing in the highly affected areas than in winter milk from the same area, spring milk from the low exposure area, or typical lead values for U.S. milk cited in literature. The effects of smelter operations on the cadmium and zinc content of the milk appeared to be insignificant relative to milk obtained from unaffected areas.

2. Evaluation: The presence of heavy metals in milk is likely due to the intake of these contaminants by cows by inhaling the contaminants, by ingesting plants growing in contaminated soils, or by ingesting plants subject to contamination fallout. At the time of sampling, the primary source of airborne contaminants had been removed with the closure of the smelter. Therefore, any elevated levels of contaminants in milk were likely due to the transfer of residual contaminants from the soil to the plant and then to the animal. This is supported by the observation that milk concentrations were observed to be highest in spring milk samples from cows grazing in the high impact area.

   Due to the amount of time that has transpired since the sampling, the data summarized in this section may not be indicative of current conditions within the Galena smelter area. However, available soil data indicates that some heavy metals may persist in the soils downwind of the smelter. Because soil is a potentially indirect source of contaminants to dairy products, and thus humans, additional soil sampling appears to be warranted to determine if the high metal concentrations still persist.

E. HUMAN AND ANIMAL DATA

1. Data: As reported by Lagerwerff and Brower (1975), samples of human blood and hair and animal blood were collected and analyzed for lead, zinc, and in some cases, cadmium. The samples were collected in areas of high and low exposure to the Galena smelter which had been in opera-

TABLE VIII-3

HEAVY METAL CONCENTRATIONS WHICH EXCEED GIVEN CRITERIA IN SPRING AND WINTER MILK SAMPLES FROM COWS IN HIGH AND LOW EXPOSURE AREAS OF GALENA, CHEROKEE COUNTY, KANSAS

Sampling Date	Owner	Exposure Area[1]	Number of Analyses	Concentrations in Exceedance of Metal Concentrations observed in U.S. Milk Samples in Literature (ppm by wet wt.) Pb	Zn	Cd	Number of Exceedances
May, 1972	A	High	3	0.14	--	--	1
May, 1972	B	High	3	0.11	--	--	1
May, 1972	C	High	3	0.10	--	0.0034	2
May, 1972	D	High	3	0.20	6.4	0.0040	3
May, 1972	E	High	3	0.15	--	0.0041	2
May, 1972	F	Low	3	--	--	--	0
May, 1972	G	Low	3	--	--	0.0038	1
May, 1972	H	Low	3	--	--	0.0048	1
May, 1972	I	Low	3	--	--	--	0
May, 1972	J	Low	3	--	--	--	0
Jan., 1973	K	High	3	--	--	--	0
Jan., 1973	L	High	3	--	--	--	0
Jan., 1973	M-1	High	3	--	--	--	0
Jan., 1973	M-2	High	3	--	--	--	0
Jan., 1973	M-3	High	3	--	7.8	--	1
Jan., 1973	M-4	High	3	--	7.4	--	1

[1] Based on past exposure to fallout from smelter; high exposure area downwind and within 2 km of smelter; low exposure area downwind and over 3 km from smelter.

-- Does not exceed applicable criteria or guidelines

Source: Reference No. 16

tion for over 20 years. Samples from the high exposure area were gathered less than 2 km downwind of the smelter while samples from the low exposure area were gathered over 3 km downwind of the smelter. The authors had identified the former area as a high exposure area based on its steep soil concentration gradients for cadmium, lead, and zinc observed in an earlier investigation. Persons sampled for blood had resided in their respective areas during the last ten years. Presented in Table VIII-4 are average concentrations of lead, zinc, and cadmium in samples of human blood and hair and animal blood collected during the investigation.

In general, the data show observeably higher concentrations of lead in the high exposure area for all three sample types. The 24 ug/dl (ug/100 ml) average concentration for lead in human blood from persons residing in the high exposure area is slightly less than the 25.0 ug/dl concentration being considered by the Atlanta Center for Disease Control as a toxic level of lead in human blood. Levels of lead in the blood of humans from the low exposure area and cows from both areas was observed to be noticeably less.

Differences in zinc and cadmium concentrations were noted to be insignificant between the two areas for all three sample types and in fact, were found to increase slightly in the low exposure area.

2. Evaluation: The relatively high lead concentrations observed in samples of human blood and hair and animal blood from the high exposure area as compared to the low exposure area are likely due to long term exposure, both direct and indirect, to airborne pollutants emitted from the Galena smelter. As indicated previously, the lead levels in human blood for long term residents of the smelter's high exposure area were slightly below the 25 ug/dl level of lead presently being considered as toxic in human blood by the Atlanta Center for Disease Control. With the closure of the smelter, the primary source of contamination was removed. However, human exposure to residual contaminants in the soil by indirect pathways may still be occurring.

It is doubtful that existing contaminant concentrations in the soil are capable of producing the levels of lead in human and animal blood that were exhibited in the high exposure area when the smelter was operational. Therefore, the results exhibited in the data for the low exposure area may be more indicative of present conditions. Based on the toxic criteria given above, lead concentrations of the magnitude observed in human and animal blood from the low exposure area would indicate that additional sampling is unwarranted.

TABLE VIII-4

AVERAGE PB, ZN, AND CD CONCENTRATIONS OBSERVED IN SAMPLES OF HUMAN BLOOD AND HAIR AND ANIMAL BLOOD IN HIGH AND LOW EXPOSURE AREAS OF GALENA, CHEROKEE COUNTY, KANSAS

Sample Type	Exposure Area[1]	Number of Analyses	Average Concentrations Pb	Zn	Cd
Human Blood[2]	High	25	24.4 ug/dl	654 ug/dl	NA
	Low	10	16.6 ug/dl	675 ug/dl	NA
Human Hair[3]	High	21	36 ppm by wt.	169 ppm by wt.	0.8 ppm by wt.
	Low	20	26 ppm by wt.	188 ppm by wt.	0.8 ppm by wt.
Animal Blood	High	23[4]	9.3 ug/dl	386 ug/dl	NA
	Low	16[4]	4.2 ug/dl	495 ug/dl	NA

1 Based on past exposure to fallout from smelter; high exposure area downwind and within 2 km of smelter; low exposure area downwind and over 3 km from smelter.

2 Donors in both exposure areas had average age in the forties and had resided in their respective areas the last ten years.

3 Hair was collected from persons having resided in their respective area for more than one year.

4 Value given for Pb. For Zn, number of samples were 24 and 18 for high and low exposure areas, respectively.

NA: Not analyzed

Source: Reference No. 16

IX. SUMMARY AND RECOMMENDATIONS

A. GROUNDWATER RESOURCES

1a. Shallow Aquifer: The existing data from the shallow wells and mine shafts suggest that natural manganese concentrations exceed Federal drinking water standards. Mine water samples contain concentrations of cadmium and zinc exceeding Federal drinking water standards, but in samples from shallow wells these two metals did not exceed the standards. These shallow wells were rather remote from the mine shafts, and therefore the shallow well samples may not reflect the actual influence of the mines on residential wells near the mines using the shallow aquifer. Specific information on residential use of the shallow aquifer is not available from the existing data base.

1b. Recommendations: As part of the Remedial Investigation a survey of residential use of the shallow aquifer outside the Galena municipal water supply service area should be performed to identify the specific population potentially subject to contaminated groundwater. Limited sampling of residential wells and mine shaft water should be performed to evaluate the risk to the population. To the extent possible without excessive investigative costs, the shallow groundwater system should be characterized to provide information on its potential as a pathway for contamination of the deeper aquifers, flow direction of future contamination, and impact of current water use.

2a. Deep Aquifer: Although lead and zinc mining has been occurring in the Galena area since 1876, the existing data from the deep wells does not suggest that the deep aquifer in the Galena area has been affected by chemical constituents associated with mine drainage. More recent changes in the shallow aquifer water levels due to the cessation of pumping following mine closure may increase the contamination potential from that suggested by the existing data.

2b. Recommendation: It is suggested that deep wells used as public water supplies in the Galena area be sampled during the Remedial Investigation and continue to be monitored for mine drainage constituents. The data obtained should be analyzed to identify any concentration trends which might indicate a change from the conditions suggested by the existing data. Additionally, existing deep wells or bore holes should be inventoried and evaluated with respect to their potential as a pathway for contamination of the deep aquifer.

B. SURFACE WATER RESOURCES

1. Short Creek: Existing data indicated that the stream section nearest Galena exhibited cadmium, lead, zinc and manganese concentrations and pH values which periodically exceed USEPA Surface Water Quality

Criteria or Federal Drinking Water Standards. Available discharge data do not provide evidence of water loss to mines. The volume of stream flow progressively increases in a downstream direction at a rate which cannot be attributed entirely to tributary discharge entering Short Creek. Therefore, the creek may be gaining water from the shallow aquifer. All tributaries entering the stream section nearest Galena have not been monitored to assess their contribution to observed concentrations and stream flow. All tributaries to Short Creek for which data exists have exhibited exceedences of water quality criteria or standards.

2. Shoal Creek: The existing data for Shoal Creek were obtained from only two locations on the main stem. The analytical results indicated that all chemical concentrations were within acceptable levels; however, only one sample, contained the complete series of tests used to indicate mine drainage contamination. No information is available on several tributaries to Shoal Creek which pass through large areas of tailings as they drain the southern portion of Galena.

3. Spring River: Existing data for Spring River, Empire Lake and tributaries to the Spring River exhibited manganese concentrations which periodically exceed Federal Drinking Water Standards. The existing data did not provide information on Spring River downstream of the confluence of Short Creek which could be used to assess its influence. The existing data did not provide information on all tributaries to the Spring River which either flow through or originate in mine influenced areas.

4. Recommendations: A limited stream discharge and sampling program is recommended to confirm the previously reported results, identify major sources of contamination, and to investigate unmonitored tributaries to Short Creek, Shoal Creek, and the Spring River which either flow through or originate in mine influenced areas.

C. AIR QUALITY

1. Summary: The Total Suspended Particulate (TSP) levels in the Galena and Tri-State area are generally within acceptable limits as compared to the National Ambient Air Quality Standards (NAAQS). The primary TSP standard of 260 mg/m was exceeded on only two occasions out of several hundred observations taken from 16 locations. Respirable particulate levels measured at Picher, Oklahoma, and Treece, Kansas, were within acceptable limits, but the sample size in this case was small.

Studies during 1970 and 1971 in areas upwind and downwind of the then active Galena smelter indicated that lead, zinc, and cadmium levels were higher in areas downwind of the smelter. However, lead concentrations from both downwind and upwind sampling locations were

always below the NAAQS standard of 1.5 mg/m. The zinc levels in 1970 and 1971 near Galena were slightly higher than expected levels in non-urban areas, based on data from the National Air Sampling Network, but were generally lower than levels reported from many urban areas. Cadmium levels ovserved by Irwin in the 1971 study indicated higher than expected levels in comparison to NASN data, but the 1970 data was within expected cadmium concentrations. Other air quality studies during 1975, 1982, and 1983 support the conclusion that levels of heavy metals on 24-hour TSP filter samples in the Galena area are within acceptable levels. The most recent data, monitoring during 1983 by KDHE, indicate that TSP and lead levels are within applicable NAAQS standards.

2. Recommendations: Limited site specific studies are recommended to acquire data that would indicate if specific mining features are potential sources of concern with respect to air quality. For example, the coarse material in the chat piles is not very susceptible to wind erosion and may not be a source of concern. However, chat covered roads in the area may be a source of concern because vehicles influence the rate of dispersion of the material into the air. Limited sampling should also be conducted to determine if any asbestos-like material or asbestos is in the area. Studies by Neuberger (1981) have raised the issue of asbestos-like materials as a potential factor in lung cancer rates in Cherokee County.

D. SOIL QUALITY

1. Summary: Sample data obtained from downwind areas during operation and shortly following closure of the Galena smelter exhibited concentrations of cadmium, led, zinc and copper higher than those obtained from areas protected from the smelter plume. Decreases in concentrations associated with distance from the smelter and deviation of the sample location from prevalent wind direction suggest that the mode of contamination was via air pollution deposition. The primary source of airborne contaminants was removed with the closure of the smelter in 1971. Levels of contaminants in soil samples taken in this area prior to and two years after smelter closure indicate the concentrations of lead, zinc, and cadmium in downwind soils decreased little, if any over the period following smelter closure. Virtually no data are available to evaluate the chemical constituents of soils outside the direct influence of the Galena smelter.

2. Recommendations: Additional soil sampling appears to be warranted in the area downwind of the smelter to confirm whether the elevated concentrations still persist.

E. SEDIMENT

1. Summary: No sediment data were available from the existing data base for either streams or lakes in the Galena, Kansas area. The most direct effects of contaminated sediments occur through physical or chemical influences upon bottom dwelling aquatic organisms and sensitive fish species. Bioaccumulation of heavy metals in fish or other aquatic organisms may occur in streams or lakes containing contaminated sediments. If these organisms are used as a human food source, a potential for human health effects exists.

2. Recommendations: It is considered appropriate to investigate the chemical content of edible aquatic organisms and of sediments in areas where deposition is expected to occur to estimate potential public health hazards.

F. BIOLOGICAL DATA

1. Summary: Existing biological results included aquatic macroinvertebrate sampling; and chemical analyses of home grown produce and vegetation, milk, animal and human blood, and human hair. The aquatic macroinvertebrate sampling indicated decreases in species diversity and density associated with mining related water quality deterioration. Chemical analyses of human food products and animal forage demonstrated that cadmium, lead, and zinc were present at levels in excess of typical concentrations. Analyses of animal and human blood and human hair indicated relative increases in lead associated with exposure to smelter air discharges. A major source of exposure to cadmium, lead and zinc was removed following the closure of the smelter.

2. Recommendations: Collection and analyses of fish flesh is recommended to determine if bioaccumulation of heavy metals is occurring. These data would be compared to heavy metal concentrations in sediments (see Section E). Assessment of residual contamination of soil resulting from smelter air pollution has been recommended in Section D. No additional biological sampling of the types previously performed appears to be required at this time. Work performed as part of the remedial investigation may however provide justification for other types of biological investigations.

BIBLIOGRAPHY

Reference No.

1. Abernathy, G.E. (1943). State Geological Survey of Kansas Bulletin 47, Deep Water Well at the Jawhawk Ordinance Works in Cherokee County, KS, 36 p.

2. Barks, J. H., (1977). Effects of Abandoned Lead and Zinc Mines and Tailings Piles on Water Quality in Joplin Area, MO, USGS Water Resources Investigations 77-75, 54 p.

3. Bohn, H., McNeal, B. and O'Conner G. (1979). Soil Chemistry, John Wiley and Sons Inc., New York, NY.

4. Federal Register (1975) Environmental Protection Agency National Interim Primary Drinking Water Regulations (as amended). 40 CFR 141.

5. Federal Register (1979) Environmental Protection Agency National Secondary Drinking Water Regulations. 40 CFR 143.

6. Federal Register (1980) Environmental Protection Agency Appendix A - Summary of Water Quality Criteria 45 CFR 231.

7. Irwin, J. C. (1971). Survey of Environmental Contaminants Near Galena, KS: Air Quality and Occupational Health Section, Kansas Department of Health, 63 p.

8. Kansas Department of Health and Environment (1980). Water Quality Investigations of Lead-Zinc Mine Drainage Effects on Spring River and Associated Tributaries in Kansas, 1978-1979, 42 p.

9. Kansas Department of Health and Environment (1981). Kansas Administrative Regulations Title 28, Article 16 - Water Pollution Control.

10. Kansas Department of Health and Environment, Division of Environment (1984). Water Quality Data for Kansas Water Year 1983, Bulletin No. 1-38, 307 p.

11. Kansas Department of Health and Environment (1984). Preliminary Air and Soil Sampling Data Obtained from J. Irwin, Chief Environmental Toxicology Section, 18 p.

12. Kansas Department of Health and Environment (1984). Partial Retrieval of EPA STORET Data.

13. Kansas Department of Health and Environment (no date). Miscellaneous Well Logs and Water Analyses.

14. Kansas Fish and Game Commission (1980). Neosho River Basin, Kansas Stream Survey, 163 p.

15. Lagerwerff, J. V., D. L. Brower, G. T. Biersdorf (1972). Accumulation of Cadmium, Copper, Lead and Zinc in Soil and Vegetation in the Proximity of a Smelter. In: Trace Substances in Environmental Health-VI, D. D. Hemphill, Ed., University of Missouri, Columbia, MO, pp 71-78.

16. Lagerwerff, J. V., D. L. Brower (1974). Effect of a Smelter on the Agricultural Conditions in the Surrounding Environment, 11 p.

17. Lagerwerff, J. V. and D. L. Brower (1975). Source Determination of Heavy Metal Contamination in the Soil of a Mine and Smelter Area. In: Trace Substances in Environmental Health-IX, D. D. Hemphill, Ed., University of Missouri, Columbia, MO, pp 207-215.

18. McCauley, J. R., L. L. Brady and F. W. Wilson (1983). A Study of Stability Problems and Hazard Evaluation of the Kansas Portion of the Tri-State Mining Area, U. S. Department of the Interior, Bureau of Mines Contract J0100131.

19. McKenna, Conner & Cuneo (1983). Proposal to List Tar Creek, Cherokee County, Kansas as a National Response Priority Under Section 105(8)(B) of the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 4 p.

20. Spruill, T. B. (1984). Assessment of Water Resources in Lead-Zinc Mined Areas in Cherokee County, Kansas and Adjacent Areas, USGS OFR-84-439, 102 p.

21. U. S. Environmental Protection Agency (October, 1983). Remedial Action Master Plan, Cherokee County.

22. U. S. Geological Survey (1976). Water Resources Data for Missouri Water Year 1975. USGS Water-Data Report MO-75-1, Rolla, MO.

23. PEDCO Environmental, Inc. (1981). Investigation of Sources of Environmental Carcinogens in Cherokee County, Kansas, Jasper County, Missouri, and Ottawa County, Oklahoma: U.S. EPA Contract No. 68-02-3173, Task No. 24, PN 3450-24, Cincinnati, OH.

24. Tar Creek Task Force, Health Effects Subcommittee (1983). An Environmental Health Evaluation of the Tar Creek Area, 36p.

25. U.S. Environmental Protection Agency (1984). RI Phase I Report: Existing Literature Review and Evaluation, Cherokee County Site, Kansas.

26. Neuberger, J.S. (1981). Cancer Mortality Excess in Counties of Missouri, Iowa, Nebraska, and Kanas--Part I and Part II, EPA Contract No. ER0575NTEX, 83p.